metal finishing

...APPLICATION, ELECTRODEPOSITION, VITREOUS ENAMELLING
...ANIZING, METAL SPRAYING and all METAL FINISHING PROCESSES

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THIS JOURNAL IS DEVOTED TO THE SCIENCE AND TECHNOLOGY OF PAINT APPLICATION, ELECTRODEPOSITION, VITREOUS ENAMELLING, GALVANIZING, ANODIZING, METAL SPRAYING AND ALL METAL FINISHING PROCESSES.

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MEETING A CHALLENGE

It can hardly be without significance that the addresses which the last two presidents of the Institute of Vitreous Enamellers have delivered on their induction, have both sought to draw attention to the fact that vitreous enamel as a finish would continue to find industrial application only so long as it continued to offer a standard of performance which could not be emulated by other finishes less costly to apply. This, of course, is simple production economics and the fact that so obvious a point has had to be mentioned at all let alone twice, is in itself evidence of the hitherto unchallenged position which has been held by vitreous enamel in certain applications. Until comparatively recently, the durability and resistance to heat, abrasion and chemical attack which are implicit in the very term vitreous, have put this finish into a position which has been virtually unassailable for applications in which these qualities are called for.

Inevitably however, with the present rapid growth and expansion in so many branches of technology, and particularly in plastics, other finishing systems have now been evolved which are able to give adequate, if not comparable, performances under some of the less exacting conditions hitherto endured solely by vitreous enamel, and it is reasonable to suppose that this process is likely to continue.

To visualize this situation, however, as sounding the knell of vitreous enamel would be both premature and ill-informed in view of the advances which vitreous enamel itself has made, both in its own technology and in its range of applications. The standards of performance of modern enamel formulations opacified with titania or zirconia, which are applied in considerably thinner coatings than were their earlier equivalents, have improved significantly, particularly in their resistance to mechanical damage.

While it may be true that a number of items of domestic equipment, which twenty years ago were familiarly finished in vitreous enamel, are now largely manufactured in other materials or with other finishes, it nevertheless is a fact that approximately three times as much enamel is applied to articles, in this country alone, as was the case in 1939. This is hardly indicative of an obsolescent finish or a moribund industry but reflects the fact that the new vitreous enamels are finding new applications.

With the rising costs of manpower, emphasis is thrown increasingly on the need for reducing the overall amount of effort which must be put into maintenance, and on this score the vitreous enamels have a great deal to offer. Hence their use in architectural and structural applications is becoming increasingly popular, particularly in the U.S.A. and on the Continent.

It is perhaps in this last respect that it may be necessary to express some concern with regard to the rate of progress in this country. The undoubtedly interesting and promising field of architectural applications for vitreous enamels is not being explored as thoroughly or effectively in the U.K. as it is in other countries, nor is there anything like an adequate availability of furnace and other equipment of a suitable size to accommodate the large panels called for in this work. Similarly much reluctance has been shown in the adoption and the development of vitreous enamels suitable for application for aluminium and the light alloys, in spite of an increasing demand in this field also.

The supremacy of vitreous enamel has been unchallenged for so long in its own fields of application, that it has perhaps been slow to recognise the growth of the challenge to its position. No one studying the reports of the Institute of Vitreous Enamellers transactions in this country, or of the Porcelain Enamel Institute's activities in the U.S.A. could maintain that, once aware of the challenge, the industry is not technologically capable of meeting it.

Talking Points by "PLATELAYER"

TOPICAL COMMENT FROM THE MAIN LINES AND SIDE LINES OF METAL FINISHING

THE MARCH OF PHYSICS

THE physical approach to the study of technical problems hitherto regarded as the province of the chemical sciences is now commonplace. A recent example is the investigation of the durability of paints on weathering. Hitherto, internal changes in paint films have been followed by chemical studies of the paint; now an entirely new field has been opened up as a result of techniques which have been developed for the testing of the physical properties of paint films after ageing or accelerated weathering. Such properties as tensile strength, flexibility, creep, and so on give a progressive picture of any deterioration which occurs in the coatings as time goes on. For the measurement of the elasticity modulus the velocity of sound in the paint film itself is being utilized, while the electron microscope enables changes to be seen long before they can be made visible in any other way.

For such control procedures as the thickness testing of metallic and non-metallic coatings, magnetic gauges are now widely used, while the recently developed thermo-electric method of measuring the thickness even of magnetic electrodeposits such as nickel on steel may, to some extent, supersede the Jet Test. All these tests have the great advantage of being non-destructive. In the analytical field, a new electronic automatic titrator automatically controls the flow of reagent from a burette and shuts it off when the end point is reached. It seems, therefore, that it will not be long before we begin to hear about the new profession of electronic chemistry.

FAIR WARNING

WHILE fully automatic plants have many advantages in the finishing industries, they are now so large and complicated that the production of an entire factory can be stopped if anything goes seriously wrong with one of them. It is for this reason that in the U.S.A. in particular automatic alarm and checking devices are increasingly being installed to forestall or indicate failures in vital components. This not only helps to reduce trouble, but serves to locate the point of failure when it does occur, as this in itself sometimes takes a long time.

One simple, and not uncommon example of the usefulness of an alarm system, is in preventing the loss of valuable plating solutions through a leak in a tank or a steam coil. Automatic units are being produced in this country which will operate a hooter or flashing light when the tank level falls below a pre-determined limit. As soon as the correct conditions are restored, the instrument resets itself to normal.

These alarms can also be usefully installed to give warning of overheated motors or bearings, incorrect liquid levels, over-speed or under-speed of moving parts, excessive pressures, etc. For places where solvent vapours can accumulate (such as where paint dipping or spraying is carried out) the system can be used to detect the presence of inflammable gases in concentrations well below the lower limits of explosive mixture.

Installations of this kind can pay for themselves on a single occasion, while more often than not insurance premiums are reduced when they are fitted. They will undoubtedly be used much more widely than they are at present.

TRADE CYCLE

IT is repeatedly stated that the British bicycle is preferred to the American machine in the U.S.A., because it is better and cheaper than the latter; this has led to strong pressure being exerted by American manufacturers on the Tariff Commission either to increase the duty on imported bicycles or to restrict their entry. One suggestion which has been made as to how British manufacturers might meet the situation is that they should *raise* their prices until they are equal to those of the American machines. It is argued that this would not affect sales, as the bicycles are better in any case, would earn more dollars, and would eliminate the validity of the pressure for tariff adjustments.

A proposal to increase prices as a means of improving export sales is indeed novel, but it has some force in this instance. If, however, British cycle manufacturers' consciences should be smitten at the thought of possibly overcharging their customers, they might consider applying the extra revenue to producing an article with a really superlative finish. In the cycle trade finish is an important selling point, and while the present standard is as good as any in the world there is always room for improvement. Cyclists take a keen interest in their machines and any deficiencies in a particular product soon become common knowledge.

If British bicycles became as renowned for finish as for design their position in world markets would be well-nigh unassailable.

POLLUTION by Metallurgical Trade Wastes

A Study of Some of the Causes and Suggested Cures

by E. W. MULCAHY

IF every form of pollution prevention was enforced on the metal-finishing industry, as it might well be in some localities owing to the complex nature of plating-shop wastes, the smaller concerns would find it difficult to carry on, but fortunately local authorities as a whole are fairly tolerant, although they themselves at times must find conditions somewhat overwhelming.

Town and river authorities are entitled to the co-operation of the industrial establishments of their area who in turn are entitled to the necessary guidance and advice to enable them to construct a suitable treatment plant for the minimum capital outlay and subsequent running costs.

Factory authorities should consider it a duty to treat their effluents in accordance with regulations in the most practical way, to ensure that public and private property and citizens' rights are not endangered.

It is the intention of this article to draw attention to (a) the effect of pollution on sewage plant and waterways, etc., and (b) the various methods of solving the problem, and some types of plant recommended for effective treatment.

The treatment of plating shop and pickling plant effluent must conform to the Public Health (Drainage of Trade Premises) Act, 1937, which states:—

"A trade effluent is any liquid with or without suspended particles of matter which is wholly or in part produced in the course of any trade or industry carried on at trade premises and in relation to any trade premises, means any liquid as aforesaid which is introduced in the course of any trade or industry carried on those premises but does not include domestic sewage.

"A formal application must be made to the appropriate authority for consent to discharge effluent to the sewers. The local authority may or may not give that consent, and if given may be subject to conditions. If, however, the applicant finds either the refusal or the conditions will afford him undue hardship, he may appeal to the Minister of Health whose decision is final."

With the introduction of the River Boards' Act, 1948, which was passed to enforce the prevention of pollution to rivers, streams and canals of the country, the administration of the problem of river pollution was converted from the handling of the problem by numerous fishery boards and municipal authorities, and transferred into the hands of an efficient organization consisting of some 30 river boards, each sufficiently organized with the necessary technical staff of engineers and chemists to promote the solution of the problem energetically.

The Public Health Act empowers the local authorities to make trade effluent byelaws.

Large cities where the sewer flow is large may allow the effluent to be discharged into the sewers at a fairly tolerant *p*H value, which calls for little more than simple neutralization which even the smallest organization can conform to with little difficulty.

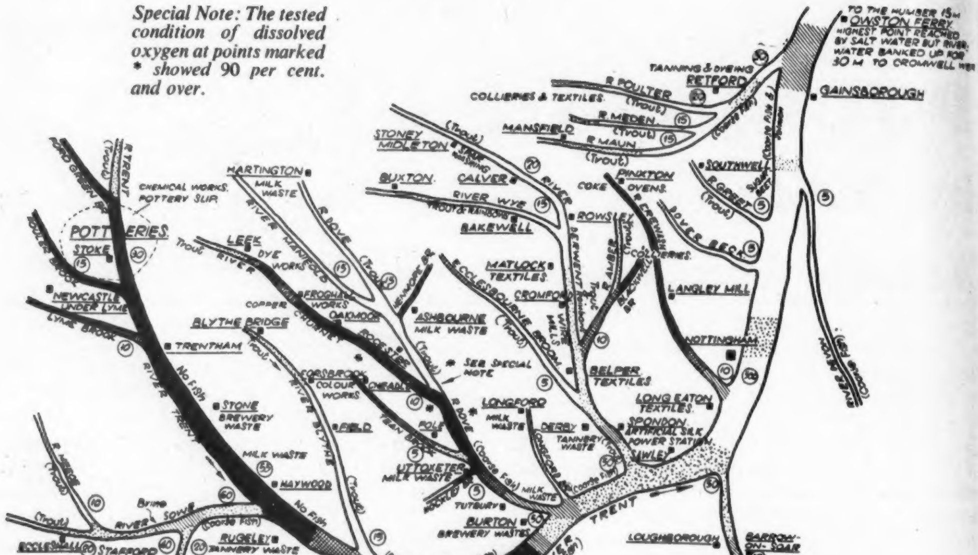
Small town authorities, where the sewer flow is comparatively small, cannot be expected to be so lenient, as pollution in this case might cause appreciable trouble to the sewage works both in the treatment of sewage and corrosion of plant, etc.

Some town and council authorities charge a levy on effluent discharged which can be roughly classified as follows:—

(a) Textile industry —2d. per 1,000 gallons.
(b) Chemical industry—3d. per 1,000 gallons.
(c) Gas works —4d. per 1,000 gallons.

Pickling- and plating-shop effluent would come under classification (b).

*Special Note: The tested condition of dissolved oxygen at points marked * showed 90 per cent. and over.*



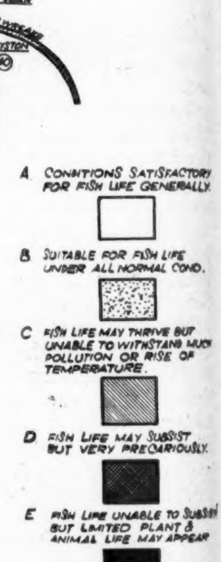


Fig. 1. Diagram showing pollution and biological conditions observed during 1945 in the River Trent and tributary streams. Approximate Scale: 7 miles to 1 inch (not uniform). Stoke to Gainsborough = 120 miles. Area of Watershed: 4050 sq. miles. Length of River Trent and 20 principal tributories = 725 miles. Population of District = 4,750,000. Approximate relationship between the biological classification and the tested conditions of dissolved oxygen.

A—over 95 per cent D.O.
B—80 to 95 per cent D.O.
C—65 to 80 per cent D.O.
D—50 to 65 per cent D.O.
E—40 to 50 per cent D.O.
F—under 40 per cent D.O.

The pollution of rivers, streams and canals is of great concern not only to authorities that control them, but to other industries that draw on these waters for processes, cooling water, etc.

Last, but by no means least, are the many thousands of anglers who spend their leisure hours in pursuit of their hobby in every part of the country. Trade establishments who discharge their effluents in streams should give some consideration to these points, and set about the task of treatment in a conscientious manner.

The objectives of treatment as far as the metal-finishing industry is concerned are summarized as follows:—

1. Removal of cyanide: concentrations of cyanide in excess of 0.1 p.p.m. as cyanide or equivalent 0.25 p.p.m. as potassium cyanide are harmful to fish.
2. Neutralization of acid or alkalis to maintain an alkaline/acidity range measured by the *p*H scale to satisfaction of the authorities.

3. Freedom from unnatural colour or surface oil film in the receiving stream.
4. Removal of suspended solids which blanket the stream bottom.
5. Reduction of concentrations of metallic compounds below limits toxic to fish and animal life.

Metals in the Effluent

The toxic effect on sewage and river life of the metallic salts included in plating-shop effluent present as big a problem to the catchment boards and sewage disposal authorities as does the acid or excess alkali content.

Electroplating wastes contain cyanides and salts of metals such as copper, zinc and chromium, which are lethal to fish, and have germicidal effect on the organisms which are responsible for the natural purification of the streams. Such wastes may, if discharged into sewers, impair the efficiency of the processes of biological oxidation of sewage and digestion of sludge at the sewage disposal works.

Effect of Waste Waters on Disposal of Sewage

The limited concentrations of heavy metals, acids, cyanides, chromium, etc., admitted to the sewage plants, are in the order of 1 to 2 p.p.m.; higher concentrations may not seriously impair the efficiency of the percolating filters, but there is, however, a danger of the filtered effluent reaching the rivers in a highly toxic condition.

Pollution of underground streams and bore holes is not uncommon in some industrial areas where discarded pit shafts and quarries are used for dumping waste effluents.

The effect of this form of pollution, though not quite so obvious, is nevertheless a problem. It so happens that in some areas where this pit-shaft dumping takes place the main water supply is from deep bore holes which are fed by a network of underground streams and pools, and very often the effect of pollution is quite evident in the water taken from these sources.

Pollution Black Spots

The diagram of the River Trent (Fig. 1) and its principal tributaries pictures the seriousness of river pollution in the watershed of the Trent Valley. The shading represents the observed biological conditions and these are given an approximate correlation with the average conditions of dissolved oxygen, the standard invariably used by local authorities to measure the recovery of a stream from pollution. The question of dissolved oxygen can be very misleading as the inclusion of heavy metals can render a river water biologically sterile, although a high dissolved oxygen figure may be still appearing.

The Black Country of South Staffordshire and the Birmingham area contributes fully 50 per cent of the pollution in the Trent Valley waters, and the Potteries of North Staffordshire fully 20 per cent. The many polluting agencies found may be grouped as to their respective contributions to the total pollution as follows:—

1. Gas and tar wastes	60 per cent
2. Chemical wastes (heavy metals, pickling acids) ...	25 „ „
3. Dyeworks, tanneries, artificial silks	5 „ „
4. Milk, brewery and sugar beet	4 „ „
5. Coal and condenser water ...	3 „ „
6. Storm water sewage ...	2 „ „
7. Domestic sewage	1 „ „

TREATMENT METHODS OF ACIDULATED WASTE WATER

Chromium

Many inorganic reducing agents are capable of reducing chromate to a chromic salt, but so far as is known only ferrous sulphate has been used in practice for treatment of waste waters. Grindley(6) has studied the treatment of waste waters containing chromate by reduction with scrap steel or ferrous sulphate. Although use of scrap steel appears attractive, it was found that reduction was very slow unless the *p*H value of the waste water was less than 3.0 and that concentrations of chromate equivalent to more than about 500 parts Cr. per million caused inactivation of the steel.

In Grindley's experiments, it was shown that when twice the theoretical weight of ferrous sulphate was used, reduction was complete in 1 hour in solutions ranging in *p*H value from 4 to 10. When reduction is complete, the chromium salt produced is precipitated by addition of lime, which also serves to precipitate any other heavy metals which may be present; heavy metals do not interfere with reduction of chromate so that waste waters containing acids, metallic salts and chromates may be treated together.

Ferrous-Sulphate Method. While the ferrous-sulphate method has the disadvantage that considerable volumes of sludge are produced, it appears to be a simple and inexpensive method for removal of chromate. It can be processed in batch or continuously. In the first stage of treatment of a collected batch of waste water, it would probably be sufficient to measure approximately the volume of liquid to be treated, and then to add for each 100 gallons of waste water

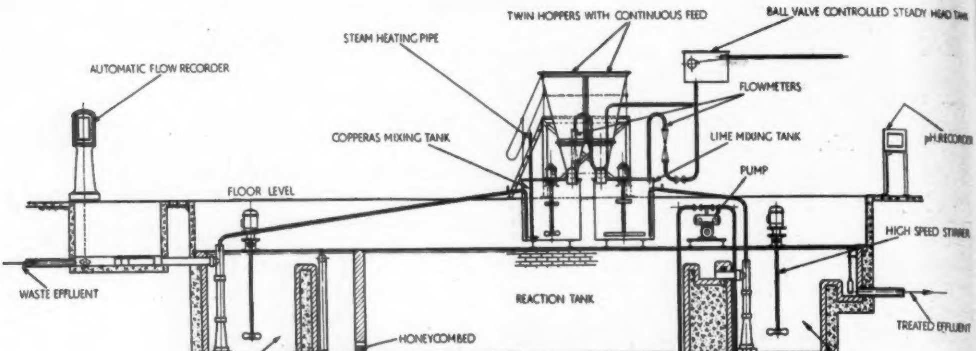
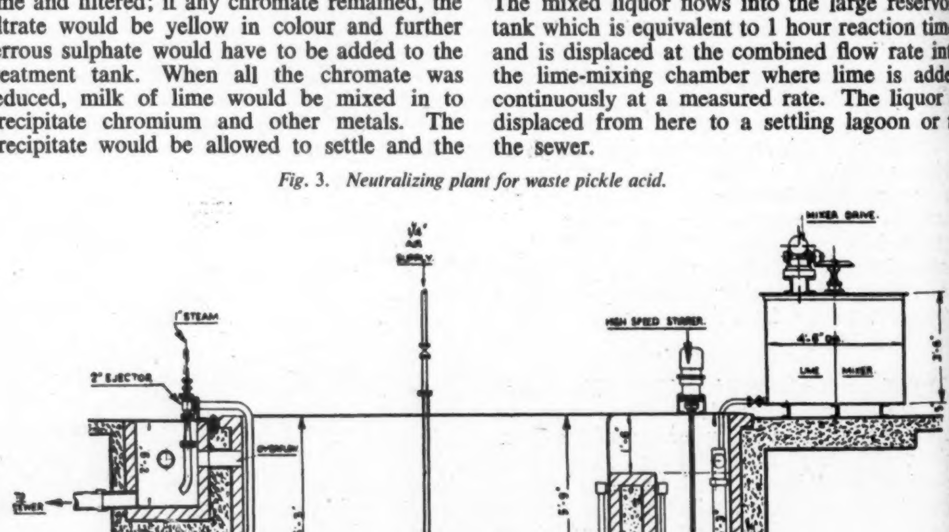


Fig. 2. An illustration of a large-scale effluent treatment plant handling rinse water from an electroplating establishment at the rate of 5,000 gal. per hr. The plant is designed for the continuous neutralization of the acidulated liquor and precipitation of chromate salts and other heavy metals in solution. The plant is designed for continuous addition of ferrous sulphate as a precipitating medium for chromic acid and cyanide in solution with a reaction reservoir and continuous limedosing section for the neutralization of the acidic effluent.

a fixed volume of a solution of ferrous sulphate, the amount being determined by experience. It would thus be unnecessary to analyse each batch of waste water. After the ferrous-sulphate solution had been well mixed with the waste water and the mixture had been allowed to stand for one hour, a small sample would be shaken with lime and filtered; if any chromate remained, the filtrate would be yellow in colour and further ferrous sulphate would have to be added to the treatment tank. When all the chromate was reduced, milk of lime would be mixed in to precipitate chromium and other metals. The precipitate would be allowed to settle and the supernatant liquid would then be ready for discharge.

With the continuous method (illustrated in Fig. 2) the solution of ferrous sulphate—equivalent of twice the theoretical amount—is fed into the incoming stream of analysed effluent, and rapidly stirred to ensure adequate mixing. The mixed liquor flows into the large reservoir tank which is equivalent to 1 hour reaction time, and is displaced at the combined flow rate into the lime-mixing chamber where lime is added continuously at a measured rate. The liquor is displaced from here to a settling lagoon or to the sewer.

Fig. 3. Neutralizing plant for waste pickle acid.



Cyanides

The removal of cyanides from trade effluents is a matter of considerable difficulty, yet the lethal nature of this chemical is such that treatment prior to disposal to either sewer or waterway is of the utmost importance. There are several methods of treatment which have met with varying degrees of success, but treatment with $FeSO_4$ and lime or hydrolysis of cyanide by chlorination are two processes which have been studied in considerable detail by the Water Pollution Research Laboratories.

(*a*) *Treatment with Ferrous Sulphate and Lime.* To obtain satisfactory results by treatment with ferrous sulphate, cyanide wastes should be treated separately from other waste waters to avoid the unfavourable effect of dilution and interference due to metals such as nickel. If the waste water is not already alkaline, milk of lime should be added. After thorough mixing of the reagents with the waste water, precipitated material is allowed to settle before the supernatant liquid is discharged. Either a batch process or a continuous process may be used. Some results of treatment in a full-scale continuous-flow plant are given in Table I.

Although cyanides cannot be completely removed by treatment with ferrous sulphate and lime, the process has the advantages that the reagents are cheap, and, as they are non-toxic, little harm can be done if excess of either is used. Treated effluent is usually suitable for discharge to a sewer, but it is not suitable for discharge to a river.

(*b*) *Chlorination in Alkaline Solution.* Cyanides can be completely destroyed by chlorination in alkaline solution and it has been reported that plants using this process have been operated in America. Although in these plants the alkaline waste waters were treated directly with gaseous chlorine, similar reactions occur if chlorine is applied in the form of a hypochlorite (" Chloros " or bleaching powder). The first reaction is the production of a cyanogen chloride.

It has been shown at the Water Pollution Research Laboratory that this reaction always occurs even in strongly alkaline solution, and particularly if an excess of hypochlorite is present, cyanogen chloride is then rapidly hydrolysed to harmless products. This method of treatment requires extremely careful control and is somewhat more complicated than the previous method. It is claimed that complete destruction of the complex cyanides of zinc, cadmium, copper, etc., is obtained.

It is obvious that only the well equipped, larger organizations should attempt this method, and even so, only after consultation with Water Pollution Research Authorities who have carried out exhaustive experiments.

TABLE I

Results of treatment of Electroplating Wastes containing Sodium Zinc Cyanide and Sodium Cuprocyanide by addition of Ferrous Sulphate and Lime in a Full-Scale Continuous-Flow Process.

Rate of flow of waste waters:
250-400 gallons per hour

Average rate of addition of reagents:
$FeSO_4.7H_2O$ 25 lb. per hour
$Ca(OH)_2$ 17 lb. per hour

day No.	Untreated waste water (Composite sample)		Treated waste water (Composite sample)	
	*p*H value	Total cyanide (p.p.m. HCN)	*p*H value	Total cyanide (p.p.m. HCN)
1	8.9	45.5	11.6	4.0
2	8.6	39.5	12.4	4.0
3	8.2	38.5	11.5	4.9
4	8.5	96.0	11.5	10.9
5	8.7	130.5	12.3	4.5
6	8.8	57.5	12.0	17.0
7	8.9	74.5	11.9	11.6

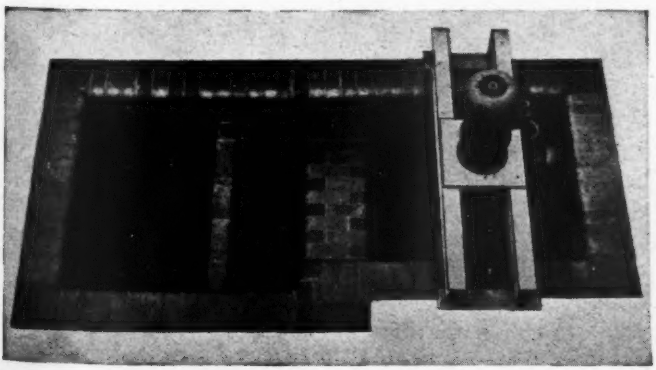


Fig. 4. Small neutralizing installation for the continuous treatment of rinse water and occasionally batch discharge from a bright-dipping shop where brass strip and pressings are treated with nitric acid bright-dipping solution. The plant is so designed that the flow rate from the installation provides the necessary time factor required for efficient neutralization and sludge precipitation.

Fig. 5. Part of a small bright-dipping shop showing acid-resisting floors and drains with the alkali feeding unit providing continuous discharge via the drains to the small neutralising plant shown in Fig. 4.

Neutralization of Acid and Precipitation of Iron

The neutralizing of waste acid effluent is a relatively simple procedure, either in batch or continuously, and even when carried out efficiently, the plant can be simple and inexpensive. If intelligent consideration is given to the design of plant, the running costs in labour and neutralizing agents, can be reduced to a minimum, in fact it is advisable on all types of treatment plants to minimize the responsibility of the operator to the carrying out of laboratory or technician's instructions.

The most effective way to neutralize acid and to precipitate iron, is by the measured dosing of continuous flows of rinse water (unless this is to be recovered as referred to later) with a solution of lime while passing through an air—or stirrer—agitated chamber. To the mixture, which will be preponderously alkaline, add a measured but continuous, small, flow of spent acid from a holding tank. The lime solution should not be more than 5 to 7 per cent $Ca(OH)_2$ to ensure a chokeless flow from the agitated feed vessel.

It is impossible and very inadvisable to attempt to neutralize the waste acids from discarded pickling tanks on a continuous flow basis unless the dilution is in the order of that referred to above.

Where the precipitation of the iron salts is demanded, the plant will need to be larger by the inclusion of a reservoir of sufficient capacity to provide the necessary precipitating reaction time and for sludge interception. It should be noted that the time factor for the reaction is important to ensure maximum iron precipitation. The reservoir should be equivalent to 1 hour accommodation. Decanting of the clear liquor will of course be continuous from this tank.

The acids normally encountered in the metal-finishing industries are sulphuric and hydrochloric for steel pickling, and nitric mixed with

Fig. 6. This plant is for handling combined volumes of rinse water and discarded waste sulphuric acid from pickle tanks treated as a batch plant by feeding milk of lime into the incoming stream, rapidly mechanically stirring and finally air agitating for the purpose of additional mixing and partial oxidation of the ferrous iron to accelerate precipitation. The treated liquor and solids are pumped to a settling lagoon where the clear liquors are decanted at a pH of 9 and are acceptable to the local river.

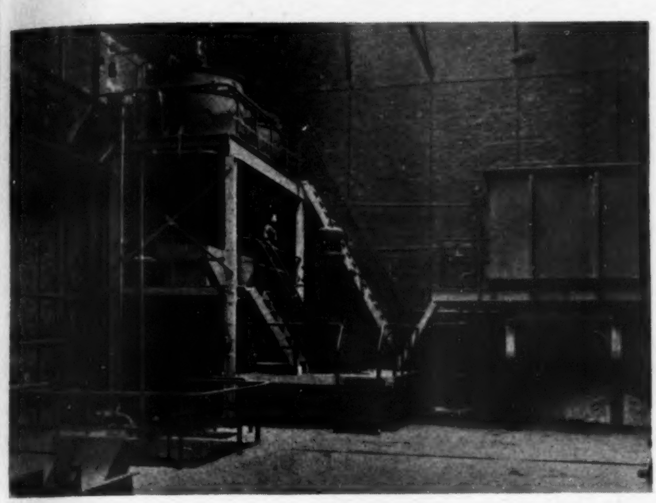


Fig. 7. A modern acid regeneration plant for the handling of spent sulphuric acid from a steel strip pickling installation.

sulphuric or hydrochloric for brass and copper bright dipping.

The plant should be well designed although not necessarily large. It is a waste of capital expenditure to construct the type of plant that has been used so often in industry consisting of over and under weir formations packed with limestone which is almost insoluble in most acidulated effluents at normal temperatures. Satisfactory results can only be achieved by the careful administration of the dosing and the intimate mixing of the resultant solutions.

Most Local Authorities insist that the acid effluents be treated to a *p*H value of 9 to ensure that the iron salts are completely precipitated, as the oxidation of ferrous iron impedes the effectiveness of the filtration plant, and also absorbs oxygen from the streams, causing unsightly discoloration of the water.

The precipitation of iron from rinse waters from either sulphuric or hydrochloric acid pickling plants needs very careful attention. When discarding, even after treatment and filtration, any remaining iron will oxidize on exposure to sunlight, and discolour the filtrate to a rust brown.

The use of compressed air from multi-jets considerably accelerates the oxidation of ferrous iron prior to filtration or precipitation when the wash water has been dosed to a *p*H of 8 to 9.

Unfortunately, some Local Authorities who are

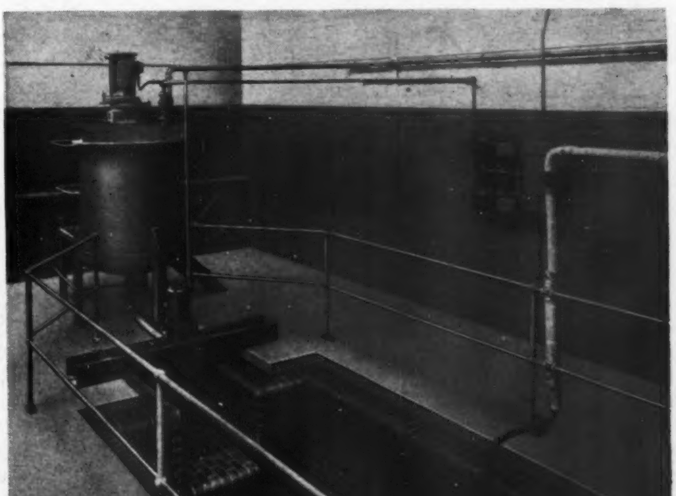


Fig. 8. An illustration of a simple type of neutralizing plant for the continuous treatment of rinse water and the batch treatment of waste pickle liquor and precipitation of ferrous salts.

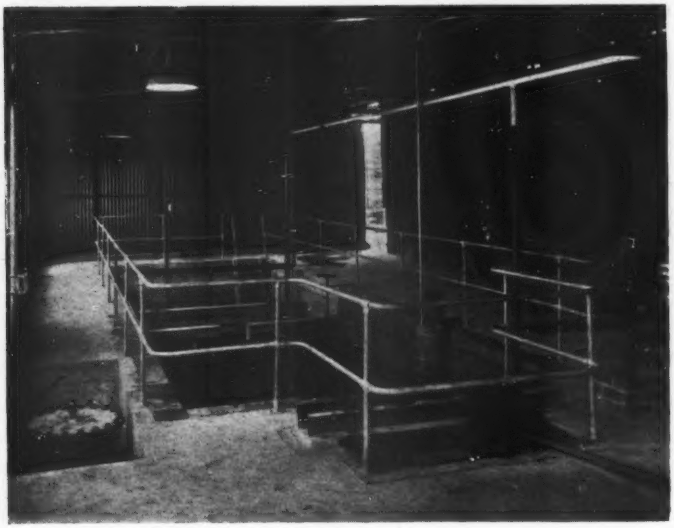


Fig. 9. View of a plant designed to handle the continuous rinse water discharge from a large pickling plant used for pickling metal parts prior to hot-dip galvanizing. Overflow from the rinse tanks is dealt with at the rate of 1,500 gal. per hr. and after neutralization and filtration is returned to the system.

not equipped with either the technical staff or the ' know how ' on the subject of pollution, tend to insist on conditions which are difficult to achieve without great cost and hardship to the industrialist.

Alternatively, through lack of experience, they may agree to certain simple proposals of plant for treatment which they consider suitable, resulting in further demands on the industrialist which may necessitate scrapping the plant and putting in a more expensive installation at a later date.

The small plant shown in Fig. 4 will fulfil adequately, the requirements of the Local Sewage Authorities when handling continuous rinse water effluents and occasional batch discharges from pickling and plating establishments up to 300 gal. per hr.

Acid Recovery

The alternative to disposal of waste effluent from sulphuric pickling plants, which represent by far the greater proportion of steel pickling installations in this country, is the regeneration of the waste acid effluent.

This is worth considering when handling tonnages of steel of the order of 2-300 tons per week which represents an approximate waste acid disposal rate of 4-5,000 gallons per week, if the Authorities insist on the neutralization and precipitation of iron from this solution. The cost for lime, loss of acid, power and labour, may well represent a figure between 3/- and 4/- per ton pickled, whereas an approximate estimate of the economics represented by the installation of an

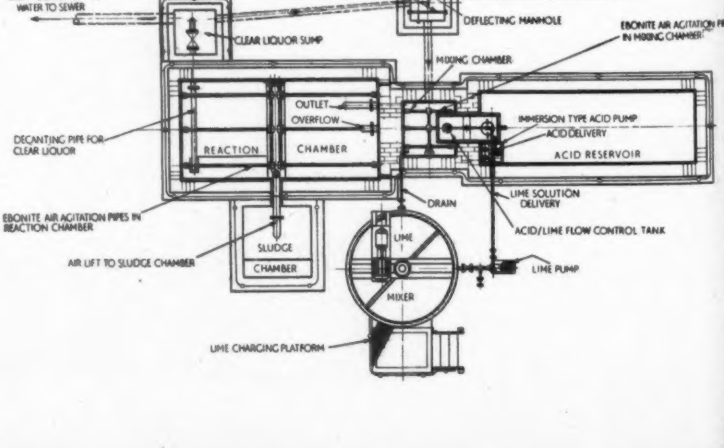
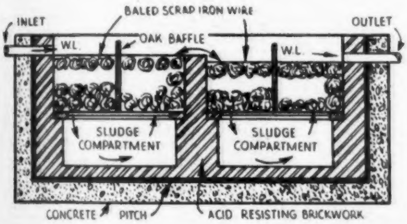


Fig. 10. An arrangement of a neutralizing plant for the continuous flow treatment of rinse water from a pickling plant and the batch addition of discarded waste acid.

acid recovery plant would represent a saving in the cost of disposal, plus a more controlled and balanced pickling. There is also a possibility of a small profit on the sale of the ferrous sulphate crystals, but with a tonnage increase over and above the stated weekly output, the question of acid recovery over disposal by neutralizing, becomes an infinitely more economical proposition.

Rinse Water Recovery

An interesting development in the disposal of waste acid effluent is shown in the illustration, Fig. 9, which is a plant designed to handle the continuous rinse water discharge from a large pickling plant for handling metal parts prior to galvanizing. The water is displaced from the rinse tanks to the above plant at the rate of 1,500 gal. per hr. and is continuously neutralized, precipitated, filtered and returned to the pickling plant after a small percentage of the treated liquor has been discharged and replaced with fresh water



to provide the necessary correction for the build-up of lime salts.

This system is so designed that during shut-down periods the contents of the hydrochloric acid pickle tanks can be neutralized in this plant before discharging to the sewer. The installation is a great asset to works where town's water is used, and where an appropriate charge is made by the Local Authorities to discard the rinse water as effluent. It certainly has an application for practically any pickling installation, and in some cases, for plating establishments where the presence of minute quantities of metallic salts, and slight alkalinity is not detrimental to efficient rinsing.

Copper

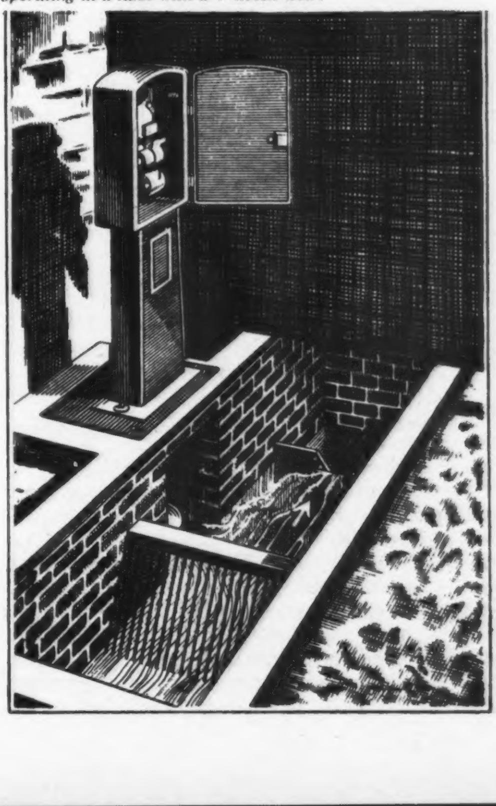
Copper can be removed from sulphuric pickling wastes by precipitation or electrolysis, and if the copper content is sufficiently high and particularly if the processes are continuous, the most economical approach to the effluent problem is the continuous regeneration of the acid and recovery of the copper by electrolysis. It is not uncommon for this method to be an integral part of a pickling installation where relatively high tonnages of copper are handled, but for the treatment of effluents where the question of copper recovery is not considered economical, neutralization by the addition of alkali either on the batch or continuous basis, is the normal procedure.

The continuous treatment of the acidulated effluent and the precipitation of the copper can be achieved by the same method applied to the treatment of waste liquor from pickling of steel, described above. The analysis of the rinse water will be fairly constant providing a regular flow is maintained, and with the addition of the contents of the batch pickling tanks at a controlled rate into the rinse water stream, effective and satisfactory results will be achieved by the measured dosing with milk of lime. It is very important to ensure that sufficient lime is added to increase the *p*H value at which the copper and zinc (if any) are precipitated, and where large flows are being handled, it is usually necessary to make frequent determinations of the final effluent by the use of a recording *p*H meter to ensure that the liquor is not toxic.

(*continued in page* 300)

Fig. 11. (left) Diagrammatic section of a small continuous flow tank packed with iron swarf for the precipitation of copper from waste sulphuric pickling acid prior to neutralization.

Fig. 12. (below) Illustration of flow recording system operating in a tank with a V-notch weir.



FINISHING POST

A SELECTION OF READERS' VIEWS COMMENTS AND QUERIES ON METAL FINISHING SUBJECTS . . . . .

Fabrication of Galvanized Holloware

Dear Sir,

I write with some concern regarding the reply given to one of your reader's queries under the heading 'Fabrication of Galvanized Holloware' in the May issue of your Journal.

Although little holloware is fabricated in this country from galvanized sheet there is to-day more tight-coated galvanized sheet made both in America and in this country than ever before, and more and more experience is being gained in the fabrication of this coated material.

Liquid-tight seams do not present a problem now that there are available so many methods of treating them. As examples, these include ready-fluxed paste-type solders and plastic bonding materials, which can be applied to the seam before forming.

Reference is also made to the service life of an article made from galvanized sheet. The advantage of the modern type of galvanized sheet is that the coating is even and there are no thin spots. Thus the chances of a reasonable life are more certain than with uneven coatings produced by hot dipping after manufacture, where similar coating weights are concerned. There has been a tendency to use gauges too thin for the application, and this, more than the coating thickness, has been a cause for complaint.

It is not, however, correct to say that the service life of articles made from galvanized sheets might be expected to be much inferior to those galvanized after manufacture.

Yours faithfully,

Banstead, Surrey. F. H. SMITH.

Painting the Britannia

Sir,

We have read with much interest 'Platelayer's' paragraph on the unregal appearance of the royal yacht *Britannia*, and we feel that this Company's experiences in connexion with the ship may serve as a complement to his remarks.

Your readers may recall the comments of Vice-Admiral Sir Connolly Abell—widely quoted in the national Press—regarding the critical condition of the ship's steelwork before she sailed to Gibraltar to meet the Royal Family at the conclusion of their world tour last year. At the time, this Company wrote to the Constructive Department, H.M. Dockyard, Portsmouth, offering to treat test sections on the ship with Jenolite RRN and Chemical Sealer on its return from Gibraltar.

Accordingly, in November last year, our Technical Department arranged treatment with the above processes of certain sections of the ship's superstructure. In March this year, a member of our Technical Department visited the Admiralty Constructive Department, Portsmouth, to inspect the treated sections and, if required, to recommend treatment for other areas of the ship, including underwater sections of the hull.

Somewhat to his surprise, he was informed that further rust removal by chemical means could not be carried out for the following reasons:

(*a*) the treated sections as yet showed not the slightest evidence of corrosion or paint failure; and

(*b*) the Constructive Department were not empowered to authorize such treatment.

The Company therefore wrote to the Director of Naval Construction, Bath. This office expressed interest and appreciation for our help. They stated also that they could not authorize treatments of this kind; though they failed, however, to mention who could.

Here, for the moment, the matter rests. You may feel, as we are beginning to, that red tape rather than blue paint has influenced paint failure and corrosion on this allegedly rust-proofed ship. However, we still think it is possible that there is an Admiralty Department capable of authorizing an effective and even, perhaps, lasting protective system for this fine ship. Platelayer may rest assured we are sparing no pains to locate that department.

Yours faithfully,
CHRISTOPHER COPPARD.

Jenolite Ltd., London, W.1.

Airless Paint Sprays

1173. We have seen references to a method of paint application by spray gun which does not require the provision of compressed air. Can you please put us in touch with any manufacturers of this equipment if there are any in this country.

There are a number of Paint application processes now available which do not require compressed air, and the use of one of these is reviewed in an article elsewhere in this issue. Addresses of manufacturers of other equipment currently or shortly to be available have been forwarded to the enquirer.

OVERSEAS REVIEW

A Quarterly Survey of some of the Features in Finishing Literature from Abroad

by **SCRUTATOR**

CORRECT cleaning is the first prerequisite of all metal-finishing operations, and during recent years the so-called di-phase cleaners have received considerable attention and publicity. In view of the claims which have been made for them, it is interesting to record that laboratory work has been published within the last month or so comparing the efficiency of a di-phase cleaner and some conventional alkaline cleaning solutions.(1) The latter consisted of sodium metasilicate, tri-sodium phosphate, sodium carbonate or sodium sesquicarbonate, either alone or as mixtures. Like the di-phase cleaner, these were used by immersion at 25°C., 50°C., and 75°C. at a strength of 2 per cent. This was selected to correspond with a partially exhausted cleaner. The test surfaces were steel specimens coated with a basic mixture of petroleum plus mineral oil plus carbon black to which stearic, oleic or lauric acid was added. Although, as anticipated, the performance of the alkaline cleaners increased with temperature, it was found that at all the temperatures tested the di-phase cleaner gave substantially more soil removal, *i.e.* it was more efficient regardless of temperature.

Stephenson(2) has also described interesting tests on the evaluation of proprietary cleaners for preparing aluminium surfaces for resistance welding. Most of these comprised a system of cleaner, de-oxidizer and fixer. Surface resistance was measured immediately after treatment, after 4 hours and then daily over a total period of 28 days. The effects of over-cleaning and over-deoxidizing were studied and it was found that some of the cleaners did not come up to the standards claimed for them.

Still on the broad subject of metal cleaning, a further use for the problem child—waste pickle liquor—has been reported.(3) It is claimed that the simultaneous removal of NH_3, H_2S and HCN from coke-oven gas can be effected by washing with the waste sulphuric-acid pickle liquor from steel plants. Pure ammonium-sulphate crystals, ferrous hydroxide and iron-cyanides are recovered in marketable form and the H_2S is processed to sulphur or to sulphuric acid, either for sale or re-use in the process. Of German origin, the American rights have been acquired by Mellon-Stuart Industrial Constructors Co.

Testing

A new approach to porosity studies of electrodeposited coatings has been suggested by the work of Wolff, Henderson and Eisler(4) who used autoradiographic techniques. In these the porosity of nickel deposits from five nickel solutions was determined by plating the nickel over an electrodeposit containing radio-active iron. The nickel solutions were representative of of the electroless, Watts (with and without proprietary brighteners), and phosphorus-containing types. The nickel films were then evaluated for discontinuities using a photographic film exposed to the radiation emanating through the nickel deposit from the iron. As yet, however, the technique is very slow as with thicknesses of 0.2, 0.4 and 0.6 mil., exposure times of 4, 6 and 11 days respectively were required. With regard to the testing of plating solutions themselves, Diaz(5) has published a useful review of the applications of polarography to the analysis of electroplating solutions and emphasis is laid in many instances on the advantages of this technique over more conventional methods.

A much more controversial topic is that of accelerated corrosion testing, in particular the salt-spray or salt-fog test. This is the subject of an editorial in the April 1955 issue of *Metal Finishing* under the title 'A Foggy Situation' which draws attention to recent work by the A.S.T.M., which has cast further doubt on the value of the standard salt-spray test B117-49T. To quote from the official findings, the test "does not reliably and reproducibly prognosticate the quality of the finishes under consideration." Nevertheless, that issue of the Journal contains a report on the salt-spray corrosion of cadmium-plated brass and steel from the Rock Island Arsenal Laboratory(6), cadmium plating on steel being one of the "finishes under consideration." Reference to the report sponsored by A.S.T.M. Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys(7) reveals that neither the 20 per cent nor the 5 per cent straight sodium chloride solution is satisfactory for the evaluation of copper-nickel-chromium coatings on steel or on zinc-base die castings, or for cadmium plating on steel. The addition of glacial acetic acid to

(*continued in page* 300)

Pollution by Metallurgical Trade Wastes

(*continued from page* 297)

If it is desirable to remove the copper content from small flows either for recovery or as an additional precaution in purifying the effluent and acidulated water prior to neutralizing, it can pass through a suitably designed tank packed with closely baled steel turnings, which is an effective method of precipitation. Where the copper will be disposed of with the sludge, the addition of ferrous sulphate as in the case of treatment of chromium waste is also an effective method.

Flow Recorders

If the Authorities require a restricted flow of effluent from treatment tanks, this can be provided for by a rectangular or V-notch weir, a system of flow control and measurement that is generally recognized as being the best for recording purposes (Fig. 10).

For the purpose of a day-to-day record of the rate of flow, flow recording meters that graphically plot the weir discharge are favoured. The meter is a float-operated unit which imparts the head of solution at the weir to a recording drum in terms of gallons per hour. The float usually operates in a separate chamber off the main stream in which the head is maintained uninterrupted by the turbulence of the flow. This ensures a perfectly well-balanced raising and lowering of the float while operating the mechanism of the recorder. If it is essential to control the rate of effluent as may well be the case in small localities, the above system of flow recording should be given some consideration.

*p*H Recorders

The electrometric method of *p*H measurement and recording is the accepted practice for determining the hydrogen-ion content of waste acids and alkaline effluents. A constant check can be maintained on the condition of the outflow from a treatment plant over a predetermined period.

The *p*H recording unit or electrometric meter consists of two immersible electrodes suspended in the solution or effluent. These electrodes are wired to the pen on the recording panel which records continuously the *p*H of the solution on the chart fixed to the periphery of the rotating drum. The function of the instrument is to interpret the electromotive force or potential difference of the electrodes in terms of *p*H value or hydrogen-ion content. The *p*H recorder will give a day-to-day reading of the hydrogen-ion content of the continuous flow of effluent. The chart chamber or recording panel can be situated remotely from the electrodes in the suitable building, protected from atmospheric conditions or dampness.

ACKNOWLEDGMENTS

The Author is indebted to the directors of Messrs. Chemical Engineering Construction (P), Ltd., for their permission to publish certain data in this article, and for the loan of photographs and drawings.

References

(1) Southgate, B.A., "The Treatment and Disposal of Industrial Waste Waters."
(2) Spicer, J. W., "The Fisherman's Struggle Against Pollution."
(3) Pettet, A. E. J., "The Disposal of Plating Shop Effluents"—*J. Electrodepositors Tech. Soc.*, 1950.
(4) Mulcahy, E. W., "The Regeneration of Sulphuric Acid in Waste Pickling Liquors"—*Industrial Chemist*, 1952.
(5) Mulcahy, E. W., "The Treatment of Plating Shop Wastes"—*J. Electrodepositors Tech. Soc.*, 1947.
(6) Grindley, J., "Treatment and Disposal of Waste Waters Containing Chromate"—*J. Soc. Chemical Industrial*, London, 1945.

Overseas Review

(*continued from page* 299)

the 5 per cent solution is confirmed as being a satisfactory modification for the accelerated salt-spray testing of many types of plated part, anodized and phosphated aluminium and some aluminium alloys. No doubt salt-spray testing will continue to be a source of argument among the metal-finishing fraternity for many years yet.

Paint

The adhesion of paint to galvanized surfaces is notoriously poor and weathering or chemical pretreatments are usually carried out before painting in order to improve this. Recent tests(8) by the Red Lead Technical Committee of the Lead Industries Association have resulted in the formulation of five red-lead paints specifically designed for application to such surfaces. The experiments were performed using weathered and chemically pretreated freshly galvanized sheets and confirmed that new surfaces which were not pretreated could not be painted effectively. They also demonstrated the ineffectiveness of such treatments as copper sulphate, acetic acid and hydrochloric acid washes and the value of a brush or spray zinc phosphate treatment. Considerable work is also going on in America on the 'deodorization' of paints, and this treatment is reported to cost only a fraction of a cent per gallon(9). It is stated that women are more sensitive to paint odours than men!

References

(1) *Ind. Eng. Chem.*, 1955, 47, (4), 845-847.
(2) *Steel Processing*, 1955, 41, (1), 31-33.
(3) *Iron Age*, 1955, 175, (12), Mar. 24, 91-93.
(4) *Plating*, 1955, 42, (5), 537-544.
(5) *ibid* 1955, 42, (4), 415-416.
(6) *Metal Finishing*, 1955, 53, (4), 48-55.
(7) *A.S.T.M. Bull.*, 1955, No. 203, Jan., pp. 62-9; T.P.23.
(8) *Paint and Varnish Production*, 1955, 45, (6), 23-26.
(9) *ibid.* 1955, 45, (3), 32, 33, 78.

ELECTROSTATIC SPRAY PAINTING

Some Details of its Practical Application in Terms of Two Typical Workshop Installations

described by E. H. LLOYD, A.I.M.

ELECTROSTATIC painting is now a well-established part of many production lines, and the use of the process confers many advantages, including saving of paint, production of uniform results, and full automation of paint application.

The process originated in the U.S.A., and the equipment is manufactured in that country by the Ransburg Electro-Coating Corp., and in the U.K. by Henry W. Peabody (Industrial) Ltd. Two processes are available under the names of the Ransburg No. 1 and No. 2 processes respectively.

The operation of both processes depends on the principle that unlike electrical charges attract each other while like charges repel. Applied to painting this principle means that the work-piece, which is earthed through the conveyor line on which it is carried through the plant, is positive in relation to the paint particles which are negatively charged. In this way the paint is attracted on to the work and overspray losses are considerably reduced.

OPERATION OF No. 1. PROCESS

The No. 1 process entails the use of a normal automatic spray gun operated by compressed air, so that atomization of the paint is effected in the usual way. In the actual spray booth the conveyor is surrounded by a wire "cage" which is large enough to allow the work-pieces on the conveyor to pass through it and at the same time to maintain as far as possible the optimum working distance between the "cage" and the work. The cage is insulated from earth and the wires of which it is composed are charged to a high negative potential; consequently an electrostatic field is set up in the space between the cage and the work-pieces which, as previously mentioned, are earthed.

As the paint droplets leave the spray guns they acquire a negative charge and tend to travel along the lines of electrostatic force in the field which is set up and consequently are attracted to the positive potential work-pieces.

The complete plant may be large or small as required, the number of spray guns used being chosen to suit the size of article being sprayed, speed of conveyor, etc., etc.

With the No. 1 process, overspray is largely eliminated but exhaust fans are still required and their influence on the air movement in the spray

Fig. 1.—The Ransburg No. 1 installation at the Cowley works of Morris Motors Ltd. General view of interior of spray booth.

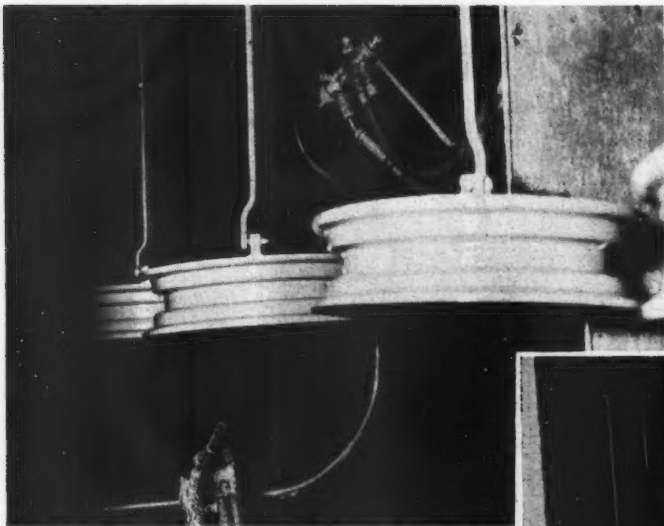


Fig. 2—(left). This illustration shows two spray guns and the wire "cage" (No. 1 process).

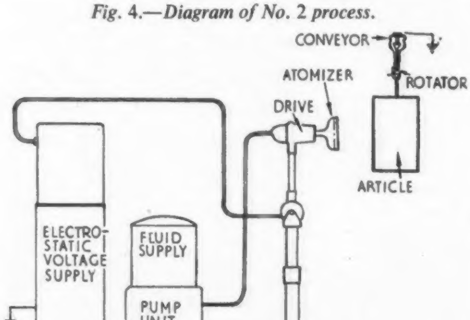
Fig. 3—(below). The additional spray gun for the deep areas of the car wheels (No. 1 process).

booth has to be taken into account in deciding the position and spraying angle of the gun or guns. The potential used is between 70 and 90 kV, and this is obtained from a high-voltage transformer fed through specialized controls from the ordinary mains supply. Although the voltage is high the total current flowing is low, being somewhere in the region of 2 m.a.

Paint saving with this process averages between 30 and 50 per cent over conventional methods, and in general the complete plant can be controlled by one operative only. Any article, where production volume justifies consideration of a conveyorized finishing operation, is suitable for treatment by the process, and non-metallic items such as wood, glass, plastics, etc., can be treated if a temporary false backing of metal is used during passage through the spray booth.

Any material which can be successfully atomized can be applied by the method, including enamels, lacquers, oils, waxes etc. Any type of conveyor is suitable, with little modification, and the air requirements of the process are easily met, the guns operating at about 20 lb. per sq. in.

Fig. 4.—Diagram of No. 2 process.



Application to Painting of Car Wheels

Typical of the No. 1 plants which have been in successful operation for some years is that at the Cowley works of the Nuffield Organization, where the process is at present being used for the painting of motor-car road wheels.

The wheels are hung on a simple overhead monorail conveyor and on entering the spray booth (Fig. 1) they revolve in the electrostatic field, the guns being positioned above and below them (Fig. 2). The wheels are revolved by the simple expedient of suspending them on a spindle which is free to revolve and which is driven by frictional contact between a wheel on the spindle and a stationary rail attached to the conveyor. This is clearly shown in Fig. 1.

An additional spray gun (Fig. 3) is included in the set-up to reach the deep areas in the wheels,

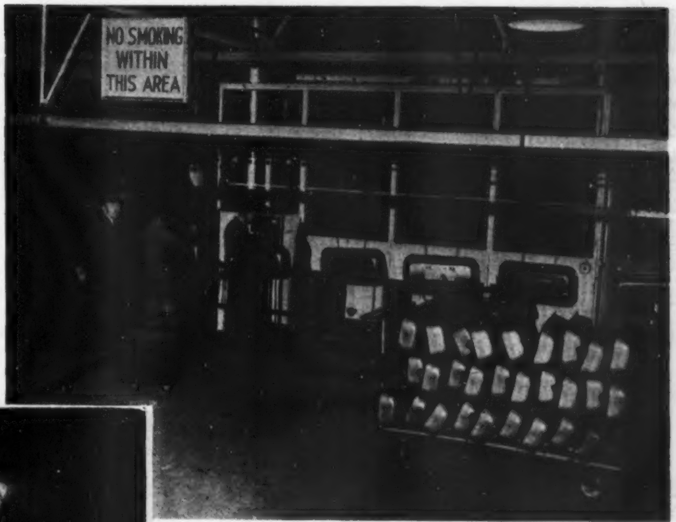


Fig. 5—(right). The No. 2 plant installed at Cowley. In this illustration the conveyor is loaded with petrol tanks.

Fig. 6—(below). Interior of No. 2 process booth at Cowley works showing the paint "bells".

which normally would suffer from a certain amount of shielding.

OPERATION OF No. 2. PROCESS

The No. 2 process, while similar in principle to the No. 1 process, is operated in a completely different manner. No spray guns are used and the use of air is not required. A diagram showing the essentials of the equipment used is shown in Fig. 4.

Atomization of the paint is achieved by supplying paint by a positive displacement gear-type pump to an atomizing "bell," which is insulated from the rest of the plant and driven at 900 r.p.m. by a laminated plastic shaft and bevel gearing. From the pump paint is delivered *via* a plastic hose to the hollow centre of the "bell" shaft and a suitable gland is used to prevent leakage. The pump speed is variable and it is by this means that the supply of paint delivered is controlled. Paint emerges from a hole

Fig. 7—(right). This illustration (together with Fig. 5) shows the wide range of components which can be painted by the No. 2 process.

Fig. 8.—General view of interior of Cowley works No. 2 installation. The method of jigging used is clearly shown.

in the centre of the rotating bell and by centrifugal force is spread to the edges. Without the high potential applied to the bell the paint would be flung off at right-angles to the axis of rotation and in relatively large particles. By applying a high negative potential to the bell and earthing the work-pieces the electrostatic force not only attracts the paint to the work but also results in an extremely fine break-up of particles giving an almost invisible mist of paint. Because of its hollow shape, the bell, in effect, throws out a hollow cone of paint which by itself cannot give uniform coverage; it is usual therefore to use the bells in units of three, each bell being positioned at a different height to give complete coverage. In each unit it is also common practice to use one large and two smaller bells.

The number of complete units used can be as many as four depending on the shape and/or length of the article being painted. The paint particles acquire their negative potential from the bells and in this process overspray is almost completely eliminated since every particle of paint is attracted towards the work-piece. Only a low-volume extractor is required on the spray booth to remove solvent vapours. By the use also of suitable size bells the size of cone can be controlled to give completed coverage all round the work-piece, moreover, the system is flexible in so far as widely differing articles can be loaded on to the conveyor as required by the production schedules.

An important feature of the process is that the considerable economies given by its use make it suitable for use by both large and small works and to amplify this it is proposed to describe two typical installations.

Application to Painting of Car-chassis Components

Well over 19,000 different components make up one Morris Minor saloon, and although the majority arrive at the Cowley works partly or wholly assembled and finished there are many which are received bare or in primer.

The Ransburg No. 2 plant installed at the works deals with a variety of components, including front suspension tie bars, brake and clutch pedals, silencer air pipes for carburettors, and fuel tanks.

The fuel tanks, shown in Fig. 5 on the conveyor, present a relatively large area, whereas for example the front suspension tie-bar is about ⅝ in. dia. Suitable racks are therefore arranged to accommodate a number of tie-bars presenting an area roughly equal to that of a fuel tank (Fig. 7). It is by careful design of the work-piece jigs that the many different components can be processed without reducing the efficiency of the plant to any great extent.

Fig. 9.—Control panel on high-voltage transformer.

Fig. 10—(above). The "Camyad" all-metal ironing table in use.

In the Morris plant six "bells" are used in two units of 3 bells each; these are shown in Figs. 6 and 8. A chassis-finishing grade of rubber-based paint is applied to the components, the final thickness being about 0.0015 in. The potential on the bells is 90 kV. from the transformer shown in Fig. 9, which also includes the control panel.

The paint, supplied ready mixed in 5-gal. drums, is not agitated, prior to feeding by gravity to the pumps, of which there is one to each "bell." The paint reservoir holds enough for a run of 90 min. and is replenished from the drums as required. In an 8-hour shift the consumption of paint is about 23 gal. Stop cocks are provided behind the bells to prevent paint dribble when the plant is not in operation. No pretreatment is given to the parts prior to painting, the finish required being that of protection only.

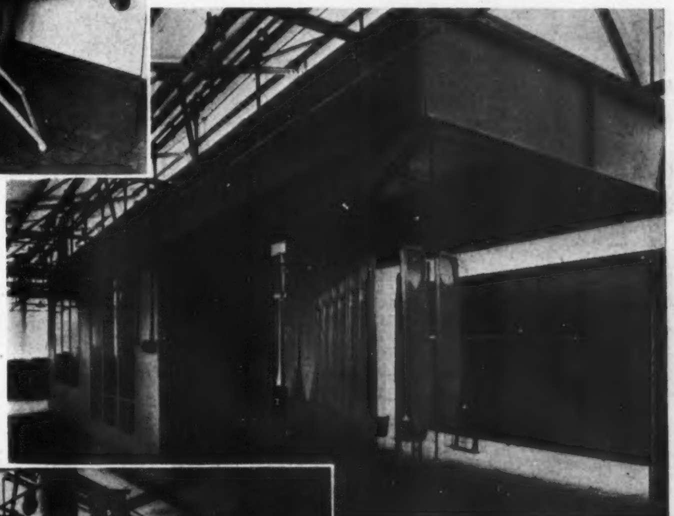


Fig. 11—(above) and Fig. 12 (left). General views of the No. 2 plant at the works of Home-Ease Ltd.

Fig. 13—(left). This illustration shows the Home-Ease plant in operation. Note the cleanliness of the backboard and the "bells" after 5-weeks' running.

Fig. 14—(below). General view of part of the interior of the Home-Ease No. 2 plant. In the background can be seen the two paint containers and the thinners container above the paint pumps.

Due to the wide variation in the shape of the parts being painted the mean distance used between the bells and the "back board" behind the work gives a slight overspray on the smaller components, but even so the paint saving is higher than 40 per cent over previous practice.

Using a conveyor speed of about 8 to 10 ft. per min. the following are typical throughput figures for several different components:

Brake and clutch pedals	9000	per week
Petrol tanks	4300	,, ,,
Rear-axle U-clips	11000	,, ,,
Tie-bars	9000	,, ,,

After painting all components are dried in an oil-fired oven.

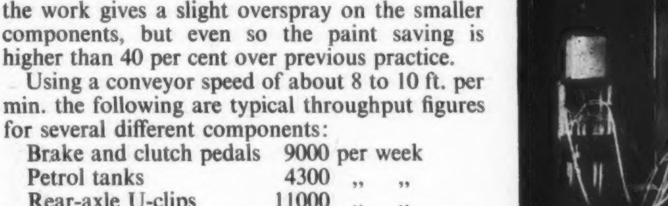


Fig. 15—(left). The loading and unloading station of the Home-Ease installation.

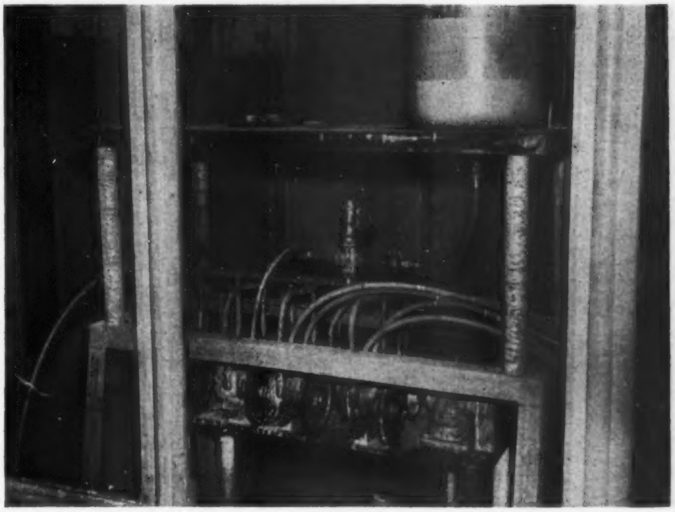


Fig. 16.—Close-up of the paint pumps. Only one paint container is shown, but the connexions for the second-colour container and the thinners container can be seen just above the pumps.

Application to Painting of Metal Ironing Tables

The second installation of the No. 2 process which is being considered is at the works of Home-Ease Ltd., Haslucks Green Road, Shirley, Nr. Birmingham. This company was started in 1947 by its present managing director Mr. J. H. Day, and in the short time of 8 years has grown to a modern albeit comparatively small works, producing as its major product under the trade mark of "Camyad", the all-metal ironing tables shown in Fig. 10. These tables, which incorporate many patented features, including that of rapid change of the ironing cloth, are exported all over the world.

The various components which make up the complete table are all produced by the company, and full use is made of the potentialities of the Ransburg No. 2 process in their final finishing. It should be emphasized here that as distinct from the Morris installation, Home-Ease use the plant for the production of a high quality two-colour finish, *e.g.*, cream and red, or cream and green, or cream and blue.

General views of the exterior of the plant are shown in Figs. 11 and 12. It can be seen that the plant is larger than that at the Morris works; in fact 12 "bells" are used *viz.*, 4 large, and 8 small. These are grouped in four units of three, each group covering a painting depth of 24 in. and each unit consisting of one large and two small "bells." The difference in the size of the two types of "bells", which have a potential of 88 kV., can be seen from Fig. 13 which shows the plant in operation painting ironing table tubular legs and the cloth retainer, and Fig. 14 which shows the pressed table tops passing through the plant. After painting the components pass through a Parkinson-Cowen gas-heated infra-red drier (seen on the right of Fig. 11) after which they are unloaded (Fig. 15).

The output of paint from the bells, for painting the tubular units is 25 to 26 cc. per min. for each large "bell" and 17 cc. per min. for each small bell. This output is proportionately higher for the table tops. With a conveyor speed of 8 ft. per min. the plant has a throughput of 320 tubular units per hour and 140 table tops per hour.

The paint used is a high-flash-point synthetic and one gallon will paint 140 tubular units and 50 tops, with a maximum wastage of about 20 per cent. As can be seen from Fig. 13 the amount of overspray is very small; the backboard is still clean even though at the time the photograph was taken, it had been in use for about 5 weeks. According to the company the main paint loss is in starting the plant up at the beginning of a working day and on closing it down in the evening. The company stress the versatility of the plant, it being possible to vary the results by such simple adjustments as the distance of the

Fig. 17.—The underside of the top of the ironing table showing the lugs which are provided for adjusting the height of the table. The shielding effect of the lugs is overcome by a preliminary hand paint spray underneath them.

Fig. 18.—Pretreatment is degrease followed by rubbing with steel wool (shown here).

backboard and "bells" from the work and by altering the speed of the paint pumps, and/or the conveyor.

Each "bell" has its own pump; Fig. 16 shows one set of pumps and one paint reservoir and the speed of the pumps can be controlled from outside the plant. When seen by this Journal only one colour was being used, but normally two paint containers, and one for thinners are connected to the pumps by the stop-cocks and pipe junctions shown in Fig. 16. A change of colour then only necessitates closing the stop-cock for the colour not required, flushing out the system with thinners, then opening the stop-cock to the second-colour container. This set-up can be seen on the left-hand side of Fig. 14.

The paint container of the size shown in Fig. 16 holds enough paint for only 100 minutes running of the plant, and as the whole of the pump unit etc. is inside the main spray cabinet the company have added a larger paint reservoir holding about 5 gal. on top of the booth from which paint is run under gravity into the container on the pump unit as required. This provides sufficient mixing of the paint before it is pumped to the "bells." A larger paint container on the pump unit would necessitate some form of agitation.

Very few difficulties have been experienced with this plant which is undoubtedly producing an extremely high-quality finish. Apart from the necessity for occasional wiping of the inside of the "bells" to remove small amounts of dried paint the main difficulty has been a local one of condensation and cold-air draughts first thing in the morning which made starting up of the plant rather difficult. This has been overcome by lighting up part of the drying equipment about 1 hr. before painting commences. The clips on the underside of the tops (Fig. 17) cause shielding, therefore the underside of these have to be given a hand spray before the tops are put on the conveyor. Welds are also given a similar treatment.

A further difficulty has been that occasional batches of tube have had very poor surface quality, necessitating the application of two paint coats, the first one being a very light "mist" coat. The design of the overhead conveyor is such that this is effected without difficulty by recirculating the components through the plant as required.

Zintec sheet is used for the table tops and pretreatment of all the components prior to painting consists of a trichlorethylene degrease followed by rubbing with steel wool. (Fig. 18). The final thickness of paint produced is 0.0018 in. on the tubes and 0.0013 in. on the table tops.

Previously all the components were painted for Home-Ease Ltd. by an outside firm, and although they are thus not able to make direct comparisons of costs, they are convinced that the plant offers the most economical method of finishing their products. It should be stated here also that the plant is capable of a much higher throughput and will thus cater for the company's steadily growing production.

Paint Quality

Generally speaking any normal industrial finish may be used for both the No. 1 and No. 2 processes, although in the case of the No. 2 process air-drying finishes or materials of a highly conducting nature require special consideration.

Acknowledgements

The author is indebted to the directors of the Nuffield Organization and Home-Ease Ltd., for granting permission to publish details of the installations at their respective works and in particular to Mr. D. V. W. Francis and his colleagues at Cowley Works, and Mr. J. H. Day managing director, and Mr. E. C. Hodgson, works manager, Home-Ease Ltd. for considerable assistance in providing the information on which this article is based.

NUMBER FIVE

METAL FINISHING RESEARCH
A Survey of its Organization, Existing Facilities and Current Work

The Water Pollution Research Laboratory

ALTHOUGH it cannot be claimed that research into methods of disposing of industrial effluents in a manner which will not lead to undesirable pollution of natural waters is directly related to the problems of producing satisfactory metal finishes, nevertheless, as is clearly brought out in the article by Mulcahy elsewhere in this issue, the problem of economic disposal of plating-shop effluents can assume major proportions.

The electroplating industry is most particularly concerned in this matter because of the nature of the solutions and materials which are in daily use, and the need for constant changing of rinse waters, and the occasional disposal of contaminated or exhausted solutions.

The substances commonly encountered in plating shops whose disposal gives rise to the principal difficulties are free mineral acids arising from after-pickling rinses or exhausted pickle liquors, the heavy metals, particularly copper and chromium, and cyanides.

Although much is now known about methods of treating polluting liquids, largely as a result of work carried out by the Water Pollution Research Laboratory, since its inception in 1927, there are still many problems which can be resolved only by carrying out further laboratory research or experimentation in pilot plants. For some industrial wastes the methods of treatment at present available are expensive, and cheaper and more convenient ones are required. It is in this field that the work of the Water Pollution Research Laboratory impinges directly on the interests of the electroplating industry.

Dr. B. A. Southgate, C.B.E., director of Water Pollution Research.

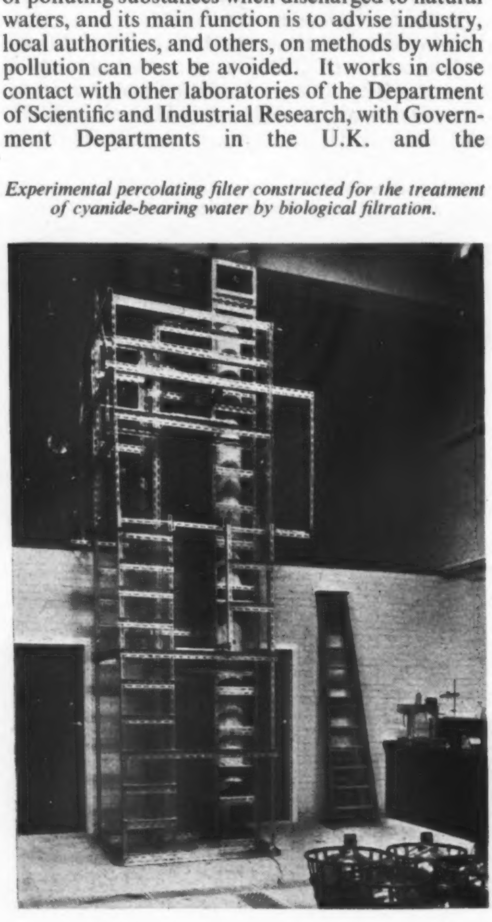
To assist in solving problems of pollution, the Water Pollution Research Laboratory carries out

The new Water Pollution Research Laboratory building at Stevenage.

A pilot-scale laboratory used for experiments in developing a standard test for the determination of the toxicity of various substances to fish.

research on the treatment of water, sewage, and industrial effluents and on the effects of all types of polluting substances when discharged to natural waters, and its main function is to advise industry, local authorities, and others, on methods by which pollution can best be avoided. It works in close contact with other laboratories of the Department of Scientific and Industrial Research, with Government Departments in the U.K. and the

Experimental percolating filter constructed for the treatment of cyanide-bearing water by biological filtration.



Commonwealth, and with Municipal authorities, water undertakings and with industry.

The diverse nature of the problems with which it has to deal is reflected in the fact that such subjects as chemistry, physics, and biology, including practical bacteriology and mycology are all represented on its staff.

Until 1954 the Organization was housed in a number of temporary laboratories with a Headquarters at Watford. All these, however, have now been closed and the whole staff is accommodated in a new Laboratory at Stevenage. This building, which was specially designed for the work, includes offices and a library, small-scale and pilot-scale laboratories, constant-temperature rooms, well-equipped workshops, and a canteen. There are facilities in the grounds of the station for carrying out large-scale experimental work on the treatment of sewage, up to 70,000 gallons of which can be pumped daily from a domestic sewer which crosses the site. It is of course still necessary to work from time to time at factories, sewage works, and other places, and to make observations on polluted and unpolluted rivers in different parts of the country. Work of this kind is usually done by sending out a team with portable equipment carried in a van or lorry, and one section of the Laboratory is continuously engaged on the development and construction of automatic recording apparatus to facilitate this type of work.

Disposal of Cyanides

As mentioned earlier one of the most highly contaminating substances normally present in plating shop effluents is the cyanide radical, and up to the present its disposal has been achieved entirely by chemical neutralizing methods, which have proved satisfactory in the main. However, as mentioned in an earlier issue of this journal, there

(*continued in page* 326)

Some Metallurgical Properties of MILD STEELS and their Influence on SURFACE FINISH

by A. W. F. COMLEY

A LARGE percentage of the articles and components which are used and sold with bright decorative finishes are manufactured from steel sheet or strip. As a general rule these articles are plated with the standard bright or dull nickel deposit together with a chromium finish. The articles themselves may have been pressed or drawn into shape prior to polishing and plating. The processes of pressing and drawing, together with the inherent characteristics of the raw material, can exert some influence on the final metal-finishing operations. The purpose of this article is to outline the various difficulties that can arise from these sources and to suggest some means of reducing their seriousness, wherever possible. It should be emphasized that the details given in the various sections are based on the author's own experience and that this article is not intended to be an authoritative survey of other published work on this type of manufacture.

There are a number of differing grades of steel available in the form of sheet and strip and to consider them all would take a great deal of time and space. However it is reasonable to assume that the greater proportion of material used for the manufacture of metal shapes which have to be polished and plated is covered by the term mild steel and it is upon this class of material that the emphasis of this article is placed.

The term "mild steel" is generally considered to refer to steels in which the only true alloying element is carbon, while the carbon content of such steels is limited to not more than 0.25 per cent. So far as the light engineering industry is concerned all the material requirements of this type of steel are covered by British Standard Specification 1449.

The following section is devoted to the groupings which are available within this specification together with the physical requirements of the specifications in each group.

RAW MATERIALS

Within B.S.S.1449 are the following En specifications which cover the various requirements of the metal-pressing industry. These specifications are dealt with in the order of reference in B.S.S.1449.

En2. Ordinary quality steel

This is an open specification, the only limiting requirements being that the carbon content shall not exceed 0.20 per cent, and that the strip or sheet shall withstand a bend test, the severity of which is determined by the material condition and thickness. The material is available in the following tempers according to the amount of cold work after annealing:

$\frac{1}{4}$ Hard. $\frac{1}{2}$ Hard. Hard. Soft.

En2A. Deep-drawing quality steel

This is a more closely controlled material than En2 and is expected to conform to the following analysis:

Carbon:	Not more than 0.12 per cent.
Manganese:	Not more than 0.50 per cent.
Sulphur:	Not more than 0.05 per cent.
Phosphorus:	Not more than 0.05 per cent.

No mechanical properties are specified.

En2A/1. Extra-deep-drawing quality steel

This is a specially manufactured material with a lower impurity limit than the two previous steels. The analysis limits are as follows:

Carbon:	Not more than 0.10 per cent.
Manganese:	Not more than 0.50 per cent.
Sulphur:	Not more than 0.04 per cent.
Phosphorus:	Not more than 0.04 per cent.

No mechanical properties are specified.

En2B. Cold-forming steel

This is a more closely controlled material than En2 but is not classed as a deep-drawing quality material. The chemical composition is as follows:

Carbon:	Not more than 0.15 per cent.
Manganese:	Not more than 0.50 per cent.
Sulphur:	Not more than 0.05 per cent.
Phosphorus:	Not more than 0.05 per cent.

A minimum physical strength is specified for this steel which enables it to be considered for stressed applications. The specified properties are determined by the material type and condition. (This is a useful specification where pressings have to be case hardened or welded as the carbon limit prevents undue brittleness after heating.)

En2C. Cold-forming material

This is a material manufactured to have a minimum ultimate tensile strength of 26 tons per square inch. It is not normally considered as a

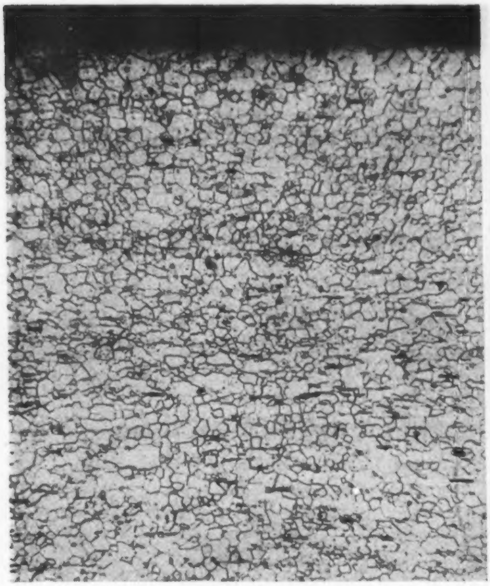


Fig. 1.—Photomicrograph of a cross-section of a killed-steel sheet showing typical clean grain structure.

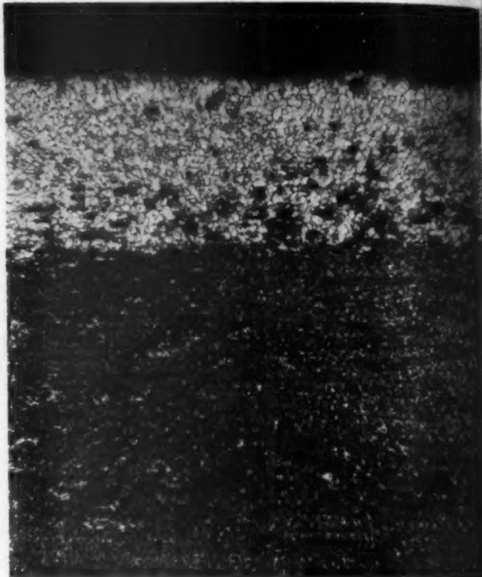


Fig. 2.—Photomicrograph of a cross-section of a sheet of rimming steel clearly showing the rimming effect which gives rise to a clean surface.

pressing material except for simple shapes. The composition limits for this steel are as follows:

Carbon:	0.15 to 0.25 per cent.
Manganese:	0.40 to 0.60 per cent.
Sulphur:	0.05 per cent max.
Phosphorus:	0.05 per cent max.

Because of its controlled physical properties this steel can be utilized for stressed applications. The properties vary according to the material condition and type.

As has been seen from the introductory remarks, the material specified in B.S.S.1449 can be obtained in the form of sheet or strip. In addition to this variation the sheet or strip can be supplied in a number of conditions, these conditions are as follows:

STRIP:

1. Hot rolled.
2. Hot rolled and pickled.
3. Hot rolled, pickled and oiled.
4. Cold rolled.
5. Cold rolled and annealed.
6. Cold rolled, annealed and pinch-passed.
7. Cold rolled, annealed and rolled to a specific hardness range.

SHEET:

1. Hot rolled.
2. Hot rolled and pickled.
3. Hot rolled, pickled and oiled.
4. Cold rolled.
5. Cold rolled and annealed.
6. Cold rolled, annealed and temper rolled.

The conditions referred to as cold rolled and annealed cover the deep-drawing and extra-deep-drawing qualities, in the case of strip; where sheet is concerned there are two general categories widely used, these are known as "general-purpose sheet" and "fully finished sheet". Fully finished material is the finest deep-drawing material available from the sheet and strip mills of this country. The majority of motor-body manufacture is done with this material.

There is one further grouping which should be discussed as it is of importance to certain aspects of metal finishing; most steels are manufactured in one of two ways and are referred to as either "rimming steels" or "killed steels". By far the greater proportion of sheet and strip is manufactured as rimming steel. The difference between the two classes of steel simplified as much as possible, is as follows: Killed steel is of an extremely high degree of purity and when the ingots are manufactured the molten metal is treated to remove all trace of gases, such as oxygen and nitrogen. Rimming steel is not treated in this way, but is manufactured so that the ingot oxide-carbon reaction purifies the outer surface of the ingot which then possesses a clean rim. Figs. 1 and 2 show the typical grain formation of both methods of manufacture. The clean rim is very obvious in Fig. 2.

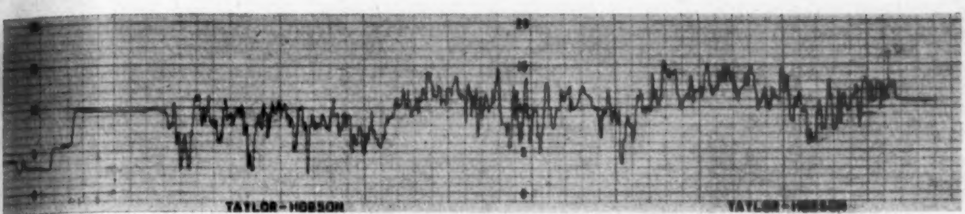


Fig. 3.—Talysurf trace of a typical hot-rolled steel strip surface.

Both of these materials have certain advantages and disadvantages when compared with each other, these may be summed up as follows:

Rimming Steel: Cheap, ductile, high degree of surface quality, easily available Susceptible to strain ageing.

Killed Steel: Dearer than rimming, more prone to surface defects than rimming, not readily available. Is not susceptible to strain ageing (to which reference is made later).

These then are the basic materials which are to be formed into various shapes and subsequently polished and plated. The next things to consider are the properties of these materials which can have a pronounced effect upon the finishing operations applied to them. These properties can have double importance as they can affect forming, and in doing so, create conditions which affect polishing or, they can have single effects on either polishing or forming alone.

The following are the properties, not necessarily in the order of importance, as this varies according to the interest of the reader.

1. Surface finish.
2. Ageing properties.
3. Ductility.
4. Grain-size.
5. Manufacturing defects such as inclusions, laps, roakes and laminations.

In the author's opinion Numbers 1 and 2 are those with which the plater and polisher are mostly concerned. Numbers 3 and 5 are more troublesome during the manufacturing stages of the article. No. 4, grain-size, reveals itself by the well-known phenomenon "orange-peel" surface; there is nothing that can be done with this as the only practical solution, re-heat treatment, is not generally possible with most sheet and strip bought for presswork.

SURFACE FINISH

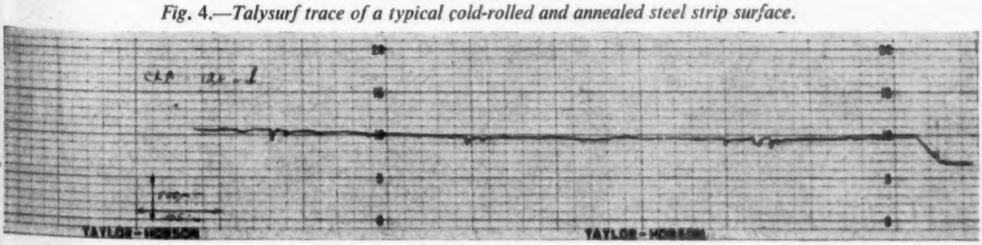
The main influence of surface finish is upon the amount of polishing required prior to the plating operation. There is a large variation between the contours of different surfaces. Fig. 3 shows a Talysurf trace of a typical hot-rolled strip surface and Fig. 4 shows the Talysurf trace of a cold-rolled and annealed strip surface.

The Talysurf graph is obtained by the use of an instrument which measures the peaks and valleys of the topography of the steel surface, the differences between the contours of the two surfaces are indicated by the peaks and valleys of the traces.

There are two main types of surface variations, there is the surface roughness, which is determined by the type of material *i.e.* hot rolled or cold rolled, then there is surface waviness which may be present in either type of steel. It is difficult to assess which variation is of the most importance but it can be said that at its worst, surface waviness is far more difficult to remove than is the roughest of hot-rolled surfaces which has no kinking present. The cause of most waviness is discussed in the next section.

One of the most unwelcome aspects of trying to assess the value of surface finish is the often complete unreliability of sheet and strip to give the expected result. It would be expected for instance that steel possessing what is known as a mirror finish would be extremely valuable for polishing and plating. The author has found instances where, when such a steel was lightly

Fig. 4.—Talysurf trace of a typical cold-rolled and annealed steel strip surface.



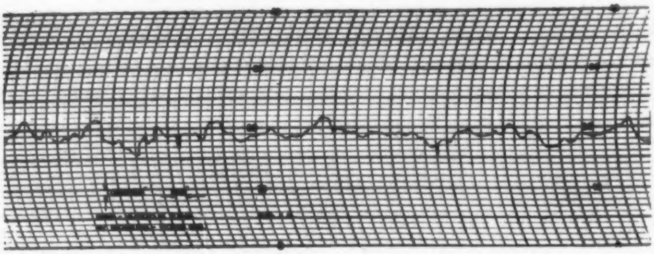


Fig. 5.—Talysurf trace of a typical cold-rolled mild steel surface.

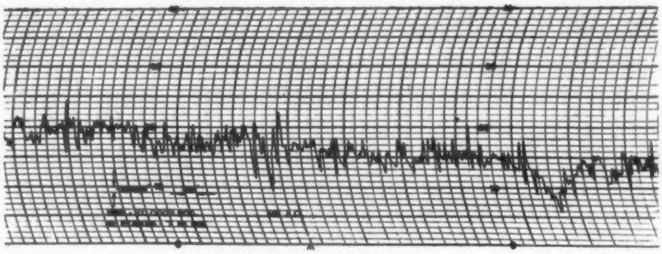


Fig. 6.—Talysurf trace of the same material as in Fig. 5 after polishing to 180 emery.

polished, subsurface defects appeared which then necessitated heavy polishing; thereupon all the value of the high finish disappeared. The normal amount of pitting and surface defects present in hot-rolled steels is often of no greater significance than the same type of defect found in cold-rolled steels. In order to illustrate the differences in surface finishes at the polishing and plating stages the following illustrations are given as typical examples:

Fig. 5 is a typical cold-rolled surface and Fig. 6 the same material after polishing to a 180 band emery. Fig. 7 shows the surface plated with dull Watts nickel. Fig. 8 is a nickel-finished surface and Fig. 9 shows Gardam Viewer reflections of the above.

The question of surface finish is one that is receiving a great deal of attention at present due to the high cost of polishing operations and a great deal of scope is present for fundamental research and for production applications of the results of such research.

Strain Ageing

One of the most troublesome defects that is met with in the polishing and plating of steel articles made from sheet and strip is the phenomena known as stretcher-strain markings.

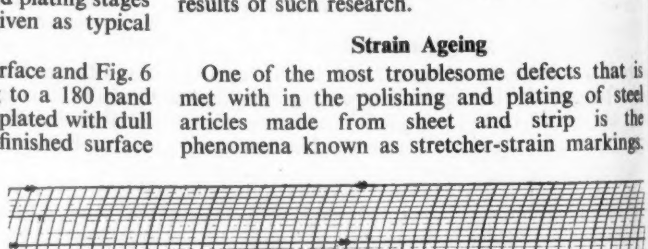


Fig. 7.—Talysurf trace of the surface measured in Fig. 6 after plating with dull Watts nickel.

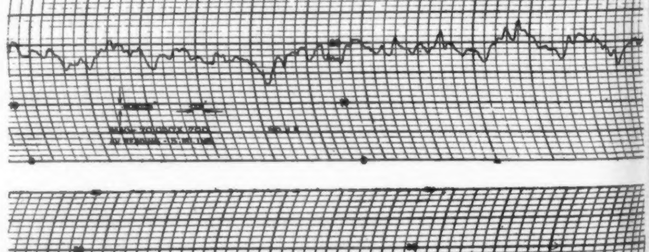


Fig. 8.—Talysurf trace of the plated surface measured in Fig. 7 after nickel finishing.

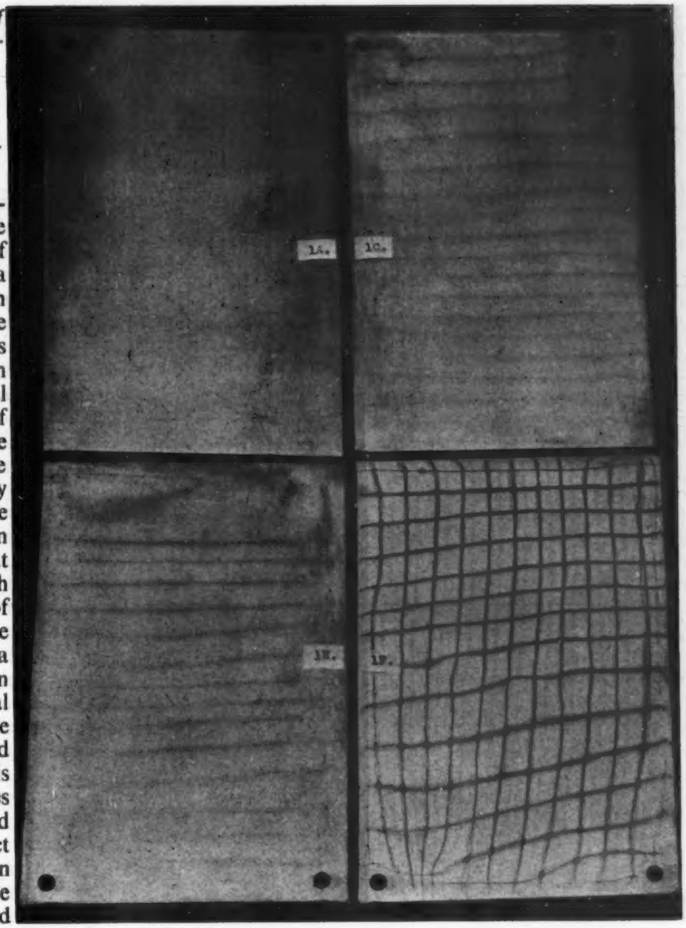


Fig. 9.—Gardam Viewer reflections of the surfaces recorded in Figs. 5 to 8.
1A. *cold rolled mild steel.*
1C. *polished to 180 emery*
1E. *dull nickel plated*
1F. *nickel finished.*

Apart from the purely mechanical difficulties it gives during the polishing of material, it is one of those problems which causes a great deal of argument between supplier and customer. The fundamental point at issue is whether strain markings are an indication of a defective material and as such the responsibility of the supplier, or are they the results of the manipulation of the material and the responsibility of the user. As is usual the answer falls some way between the two points. The fact is that strain ageing is a condition which is a physical characteristic of rimming steel in exactly the same way as age-hardening is a characteristic of Duralumin alloys. Much investigational work has been done into the actual causes of strain ageing and the generally accepted theory is that the basic cause is the gases which are present in the steel and that the reason for the gas effect is to be found in the "dislocation theory of strain ageing". The discussion of such a theory would be out of place in an article such as this but for those who wish to investigate further a list of published works is appended. It should be pointed out that stretcher-strain markings almost invariably occur in pressings which have had a relatively light draw; deep drawn areas do not normally suffer.

In the eyes of the polisher and plater, strain markings are bands in the material which become more obvious the more it is polished, until when reflectivity is at a maximum, the strain markings are most pronounced. The reason for this is that the surfaces of the strain bands offer differing reflection facets to the light and the more the facets are polished the more efficiently they break up the light. A simple analogy would be a diamond which in its unpolished state appears smooth and matt; when planes are cut and polished then the surface faceting is apparent.

Fig. 10 shows a Talysurf trace of the surface of some fully finished sheet. Fig. 11 shows the same material after it has been formed with resulting strain markings, the difference in the two surfaces can be seen to be very marked. Fig. 12 shows the actual material surface with the flamboyant markings.

As to what can be done to prevent these markings, there are two methods of approach; one is positive, the other is semi-positive. The positive way is to manufacture killed steel only but unfortunately due to the shortage of steel and because the method of manufacture means a lower ingot yield this is not possible at the moment; in this direction the general hope lies in finding alloy additions which will not increase the cost of the steel to an uneconomic degree, but will prevent the physical changes within the steel that cause strain ageing.

The semi-positive way is to reduce temporarily

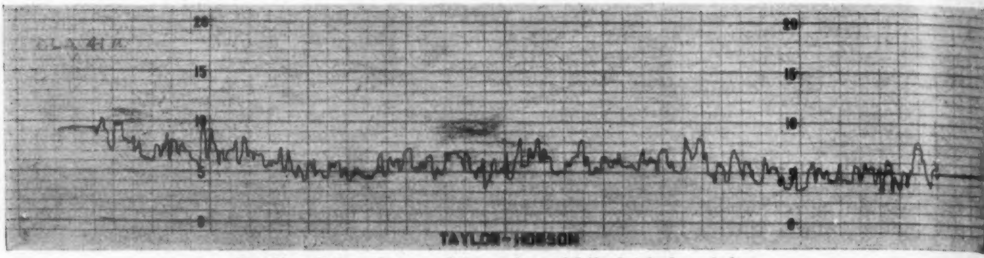


Fig. 10.—Talysurf trace of the surface of fully finished steel sheet.

the ageing effect by inducing a controlled amount of cold work into the steel. This method is known as pinch passing in the case of strip, and temper rolling in the case of sheet; again a great deal of investigational work has been done in order to determine the precise effect of this cold work and no attempt will be made here to discuss the theoretical implications of the process. The following paragraphs give a general outline of the methods for determining the existence of stretcher strain tendencies, and the type of machines used in an attempt to overcome it.

Pinch passing and Roller levelling

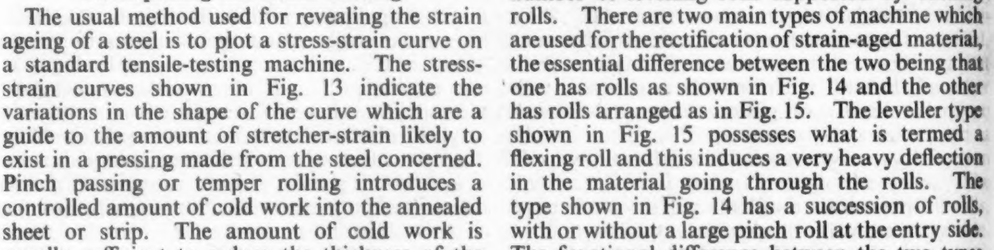
The usual method used for revealing the strain ageing of a steel is to plot a stress-strain curve on a standard tensile-testing machine. The stress-strain curves shown in Fig. 13 indicate the variations in the shape of the curve which are a guide to the amount of stretcher-strain likely to exist in a pressing made from the steel concerned. Pinch passing or temper rolling introduces a controlled amount of cold work into the annealed sheet or strip. The amount of cold work is usually sufficient to reduce the thickness of the material by about 1 per cent, *i.e.*, 0.001 in. on a material 0.1 in. thick. When an annealed material whose stress-strain curve is as shown in Fig. 13(*a*) is subjected to this cold work the irregularities at the yield area are flattened out and the curve becomes smooth as shown in Fig. 13(*d*). When this has been done the material will not normally exhibit stretcher-strain markings. The disadvantage of this method is that the effect wears off after a period of time which varies according to the material, the temperature of storage and the consistency of the cold work. When this effect passes off then the strain marks can return and in addition the material can be more difficult to work; fortunately there is a remedy for this and that is by using a machine termed a roller leveller.

Roller Levellers

The roller leveller is a machine which was originally designed to straighten or level steel sheets and in its simplest form consists of a number of levelling rolls supported by backing rolls. There are two main types of machine which are used for the rectification of strain-aged material, the essential difference between the two being that one has rolls as shown in Fig. 14 and the other has rolls arranged as in Fig. 15. The leveller type shown in Fig. 15 possesses what is termed a flexing roll and this induces a very heavy deflection in the material going through the rolls. The type shown in Fig. 14 has a succession of rolls, with or without a large pinch roll at the entry side. The functional difference between the two types is that the flexing roll machine is only suitable for material up to 0.064 in. thick whereas the other is capable of dealing with material with thicknesses of the order of 0.125 in. In the author's opinion the flexing roll machine is a much more positive method than the other and is extensively used to process material for motor-car bodies, which is relatively thin steel sheet.

Roller levelling on its own, that is on non-pinch

Fig. 11.—Talysurf trace of a fully finished steel sheet surface after cold forming has resulted in the production of stretcher-strain markings.



passed material, does not seem to be very successful probably due to the fact that the machines do not put in sufficient work to affect markedly the yield point of the steel.

There is one type of strain marking with which roller levellers are often expected to cope and yet are usually far below the power requirements; this is what is termed coil breaks or coiling kinks. This defect appears when strip material is being uncoiled and it takes the form of a ripple or kink across the strip width. The only sure way of removing this is by the use of a pinch passing mill of the type used by strip manufacturers, a piece of equipment not usually available in light engineering factories.

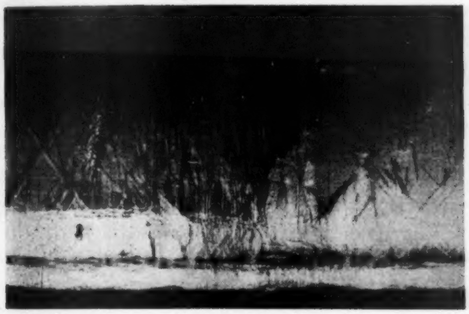


Fig. 12.—Surface of a fully finished steel sheet after cold forming showing stretcher-strain markings.

Strain ageing can be overcome by using materials of a higher carbon content that is about 0.25 per cent and also by using a low-carbon-content steel in the cold-rolled condition, but the ductility suffers and other problems occur.

PRESSWORK

The main influence of presswork upon steel which is to be subsequently polished and plated is the deformation or damage to the significant surfaces. The strain markings in the previous section are one of the most common but are confined to material which is susceptible, and are not really a pressing defect. The most serious feature which need not necessarily be influenced by the material being pressed is the damage caused by tool pick-up and scuffing. This type of defect can be caused by a number of conditions each of which are considered in the next sections.

Scoring due to foreign matter

Foreign matter which becomes interposed between the mating surfaces of the punch and die and work is probably the most persistent offender. This is one of the perpetual problems of most press shops, the solution is simple, complete cleanliness. This solution however is not so easy to apply. The source of the foreign matter can usually be found in the following places:

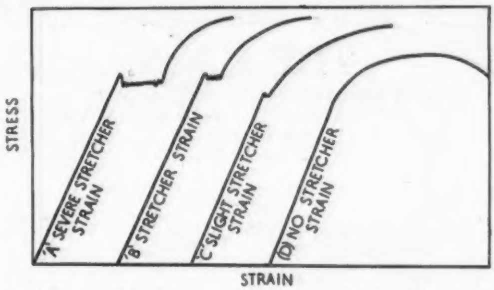


Fig. 13.—Series of stress-strain curves indicating the possible variations in the shape of the curve and the consequent tendency to stretcher straining.

1. Surface of the material being pressed, having been picked up in transit and retained by the thin grease film present on most materials.
2. Present on the tool after having been airborne in the press shop.

In order to illustrate the varied nature of such pick-up the following is an analysis of material scraped from a large pressing that has scored very badly. The tool was cast iron and the pressed material, fully finished sheet.

Ferrous material:	30 per cent approx.
Carbonaceous matter:	25 per cent approx.
Copper:	5 per cent approx.
Aluminium:	6 per cent approx.
Silica:	34 per cent approx.

It is possible to effect a measure of prevention by educating press operators to clean the surface of work and tools. It may well be that the solution to this problem lies in the future when flow-line techniques are well established in press shops and material cleaning is a line operation.

(*continued in page* 326)

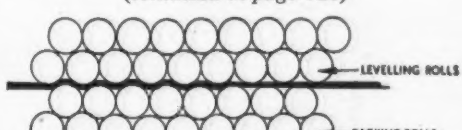
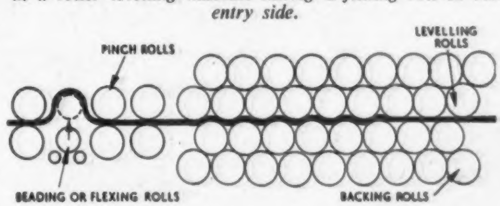


Fig. 14.—(above) Diagrammatic arrangement of rolls in a roller levelling machine.

Fig. 15.—(below) Diagrammatic arrangement of the rolls in a roller levelling machine having a flexing roll at the entry side.



A Brief Description of THE G.K.N. CURRENT DENSITY METER

Introduction

THIS device was developed by the G.K.N. Group Research Laboratory at the suggestion of the Ionic Plating Co., and although at present in the laboratory stage of development it is hoped to make the instrument generally available to the industry.

The polythene-coated ring probe measures the true plating current density in any given region of a plating bath, and in particular over the cathode or anode surfaces.

The novel feature of the device is that the measurement is obtained by virtue of the magnetic effect of the plating current on closed magnetic cores in the ring probe. No electrical contact exists between the measuring circuit and the plating bath, and the probe is completely insulated from the solution by the polythene coating. Thus the probe does not produce any local electrical interference or modification of the natural current distribution in the bath. There is inevitably a certain modification of the lines of current flow due to the introduction of an obstruction but this error is quite small.

The instrument is battery driven, incorporating normal portable-radio type batteries and valves, and has been designed for ease of use on the shop floor. The plating current density, for a given probe situation, is indicated in amps per square foot on a meter after a simple Wheatstone bridge balancing operation has been carried out with a single knob control.

Simple explanation of operating principle

(1) The probe magnetic core and the dummy magnetic core are nearly identical and the a.c. bridge is balanced when $\frac{L}{L^1} = \frac{R}{R^1}$

(2) A d.c. current I (*i.e.* plating current) flowing through the probe ring magnetizes the core and alters the inductance L, throwing the bridge out of balance.

(3) Current i flowing through a separate winding on the core annuls the magnetization due to I and the bridge is restored to balance when $ni = I$.

Thus the milliammeter A can be calibrated in terms of I, or plating current density, since the probe is a fixed area and I = Area × Plating Current Density.

More precise explanation of operation

While Fig. 1 demonstrates the principle of operation, a single probe core could not actually be used in a plating solution because of transformer action between the winding L and the plating solution—the latter acting as a shorted single-turn secondary winding. This difficulty is overcome by having two cores in the probe ring as shown in Fig. 2. The a.c. flux is in opposing sense in the two cores and therefore eliminates transformer action on overall linkages such as the conducting solution of the plating bath; to be quite certain of this a deliberate short circuiting winding is permanently incorporated. The sensitivity of the inductance L. to d.c. polarization has not been impaired by this arrangement, and in practice both the probe ring and the balancing coil are composed of such double cores.

(*continued in page* 326)

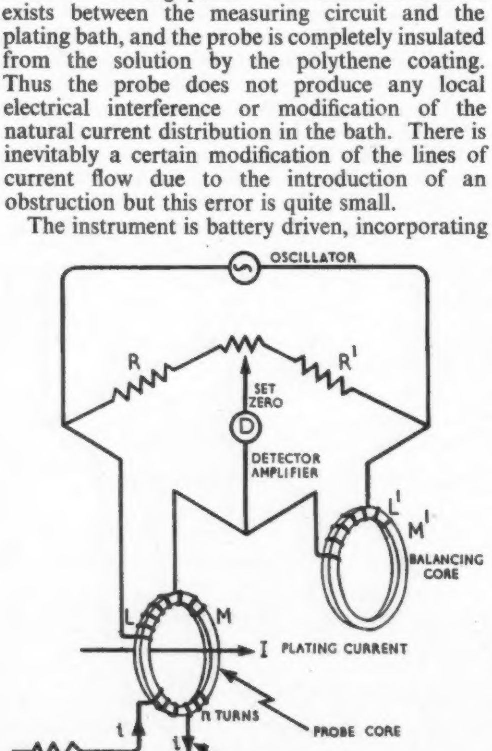


Fig. 1 (left)—Diagrammatic layout of wiring circuit for current density meter.

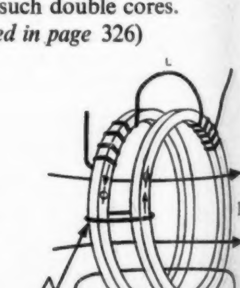


Fig. 2 (right).—Double core arrangement of probe for counteracting transformer action.

The Electrolytic and Chemical Polishing and Brightening of ALUMINIUM and its ALLOYS

A Review by A. W. BRACE, A.I.M.*

(Concluded from page 278, June, 1955)

Chemical Polishing and Brightening Mixtures

Chemical polishing baths are mainly of the phosphoric-acid or acid-fluoride type. The former can remove moderate amounts of metal while the latter produces only a slight smoothing, but a definite brightening. It is possible to give only a general indication of the properties of these baths as no systematic comparison has yet been made.

(a) Phosphoric-acid-based Solutions

The simplest chemical-polishing mixture used on aluminium is a phosphoric-/sulphuric-acid mixture known as Alpol which is patented by United Anodizing Ltd.(26). It usally consists of 70 per cent phosphoric acid and 30 per cent sulphuric acid used at 90 to 110°C. although a 50/50 mixture of the two acids has also been used.

It is quite widely used commercially in this country, either as a finish in itself or protected by lacquering or subsequent anodizing, and it is most successful with aluminium of 99.0 to 99.8 per cent purity. A total reflection factor of 78 per cent on commercial-purity and 82 per cent on super-purity aluminium is reported by Henley(27) for anodized reflectors processed in this way, although the diffuse component is fairly high.

A further development of the phosphoric-sulphuric bright dip is the addition of nitric acid. Herenguel(28) has indicated that with aluminium of 99.0 per cent purity upwards polishing can be produced by dipping the component first in a sulphuric-rich mixture such as 50 per cent phosphoric acid, 40 per cent sulphuric acid and 10 per cent nitric acid (by volume) at about 100°C. and then into a phosphoric-based mixture, *e.g.* 75 per cent phosphoric acid, 20 per cent sulphuric acid, 5 per cent nitric acid at 100°C. The first mixture removes appreciable metal, with the evolution of gas, while the latter pro-

Fig. 5.—Bottles in commercial purity aluminium (Material S1C) after spinning and anodizing only (right) and (left) mechanical polishing, brightening in "Kynalbrite" phosphoric-sulphuric-nitric mixture and anodizing.

* Metallurgist, The Aluminium Development Association, London, W.1.

TABLE II

Chemical polishing and bright dipping baths

Phosphoric-acid-base Mixtures

(1) Alpol

	volume
Phosphoric acid	75%
Sulphuric acid	25%

Temperature 90 to 110°C.

(2) Procol

	volume
(a) Phosphoric acid	50%
Sulphuric acid	40%
Nitric acid	10%

Temperature 100°C.
Time ½ to 2 min.

	volume
(b) Phosphoric acid	75%
Sulphuric acid	20%
Nitric acid	5%

Temperature 100°C.
Time 2 to 5 min.

(3) Alubril I

	volume
Phosphoric acid	48%
Nitric acid	31%
Sulphuric acid	21%
+ Cu acetate	1%*

Temperature 110°C.
Time ¼ to 1 min.

(4) Alubril II

	volume
Phosphoric acid	86%
Sodium nitrate	9%
Sodium sulphate	4%
+ Cd nitrate	1%*

Temperature 100 to 130°C.
Time up to 10 min.

(5) Alupol I—Alkaline

Caustic Soda	450 gm.
Sodium nitrate	450 gm.
Sodium nitrate	250 gm.
Sodium phosphate	200 gm.
Water	200 gm.
Cu, Zn or Ni Nitrate	3 gm.

5 sec. to 2 min. at 140°C.

(5) Alupol II

	volume
Phosphoric acid	80%
Acetic acid	15%
Nitric acid	5%
+ Heavy metal salt	¼%*

Temperature 90 to 110°C.
Time 2 to 5 min.

(6) Alupol III (similar to R.5)

	weight
Phosphoric acid	50%
Sulphuric acid	25%
Nitric acid	6½%
Acetic acid	6%
Water	12½%
+ Heavy metal salt	¼%*

Temperature 90 to 95°C.
Time 2 to 5 min.

(7) Alupol IV

	weight
Phosphoric acid	41%
Sulphuric acid	25%
Nitric acid	30%
Boric acid	4%

Temperature 90 to 95°C.
Time 1 to 5 min.

Acid Fluoride Baths

(1) Kaiser Aluminum Corpn.

	weight
Nitric acid	2.5%
Chromic acid	0.6%
Ammonium Bifluoride	0.6%
Glycerol	0.6%
Cu nitrate	0.05%†
Water	rem.

Temperature 90 to 100°C.
Time 3 to 10 min.

(2) General Motors Corpn.

	weight
Nitric acid	3.75%
Ammonium Bifluoride	0.65%
Chromic acid	0.65%
Ethylene Glycol	0.60%
Cu nitrate	0.0025%†
Water	rem.

Temperature 90 to 100°C.
Time 3 to 10 min.

(3) Vereingte Aluminium-Werke

	weight
Nitric acid	13%
Ammonium Bifluoride	16%
Lead nitrate	0.02%†
Water	rem.

Temperature 55°C.
Time 15 to 30 sec.

* Maximum specified † Preferred amount

duces polishing by the action of a viscous layer. The higher phosphoric-acid contents enable alloys to be polished, but the use of the first type of bath (low in phosphoric acid) is not recommended with alloys because pitting tends to develop which is not readily eliminated in the second bath. This process is offered commercially in France under the trade name "Brillotalu." A similar mixture has also been offered in this country as "Kynalbrite" but the nitric-acid content is higher and some ferrous sulphate is added. (*See* Fig. 5.)

Another mixture of the same type is that known as Alubril I, developed by the Institute Sperimentale di Metalli Leggeri[29], and contains nominally 48 per cent phosphoric acid, 31 per cent nitric acid, 21 per cent sulphuric acid, to which 1 per cent of copper acetate may be added. An immersion time of 15 to 60 sec. at 110°C. is recommended. The bath brightens commercial-purity aluminium, but a marked gas evolution occurs at the surface accompanied by the release of unpleasant nitrogen-peroxide fumes. The nominal composition and operating conditions of this and other chemical baths are summarized in Table II.

In addition to sulphuric and nitric acids other weaker acids such as acetic are sometimes

Fig. 6.—The front and rear bumper mouldings and overriders of the 1954 "Vega" Bedford coach are in a super-purity aluminium/1½ per cent magnesium alloy, "Brytal" treated and anodized.

incorporated. Thus the Alupol II dip of Vernal S.A., Geneva, uses acetic instead of sulphuric acid and consists of 80 per cent phosphoric acid, 15 per cent acetic acid and 5 per cent nitric acid with an optional addition of up to 3 per cent of a heavy-metal salt (*e.g.*, Cu, Ni, Zn, Cr, or Co.).

A further development of the Alupol II bath is the Alupol III composition(30) which contains acetic acid in addition to the previously mentioned acids. A nominal composition quoted is:—

	By Weight
Phosphoric acid	25 per cent
Sulphuric acid	50 „ „
Nitric acid	6½ „ „
Acetic acid	6 „ „
Water	12 „ „

About 0.3 per cent Ni (or Cu, Co, Zn, Cr) salt may be added

Temperature 90 to 95°C.
Time 2 to 5 min.

This bath, which is similar to the Alcoa R.5 bright dip(44) is particularly useful for components which only require a bright finish and may not be subsequently anodized, although it is widely used in the U.S.A. by anodizers.

Another modification which has been indicated by the same company is the incorporation of boric acid (or other acid forming a complex with phosphoric, *e.g.* molybdic) into such mixtures. A typical composition coming in the patent(31) range contains:—

	By weight
Phosphoric acid	41 per cent
Sulphuric acid	25 „ „
Nitric acid	30 „ „
Boric acid	4 „ „

Temperature 90 to 95°C.
Time 1 to 5 min.

No mention is made in the patent literature of the incorporation of a heavy-metal salt, but the brightness is considered satisfactory without it. No experience is available in this country with this bath (Alupol IV), although the patentees state that it is used on the Continent for alloys except where the silicon content exceeds 1 to 2 per cent.

It is possible for some of the acids to be replaced by their salts since the oxidation/reduction mechanism will still operate. An example of this type is the Alubril II bath (I.S.M.L.) containing 86 per cent phosphoric acid, 9 per cent sodium nitrate, 4 per cent sodium sulphate, and 1 per cent cadmium nitrate which operates at 100 to 130°C. with an immersion time of up to 10 min.

(b) Alkaline Bath

The first chemical polishing bath, announced by Vernal S.A.(23) and known as Alupol I, was essentially an alkaline bath based on sodium hydroxide with sodium nitrate, nitrate and phosphate present together with water. This bath is no longer used commercially because the attack is too violent and not readily controlled, only 10 to 20 sec. treatment being normally required. A similar bath is covered by a recent Italian patent(45), and consists of 2 parts (by wt.) sodium hydroxide, 2 parts sodium nitrate, 0.3 parts sodium silicate and 0.5 parts water heated at 120°C., but it suffers from the same disadvantages as the Alupol I bath. Attempts to produce a more dilute alkaline bath without these difficulties have not so far been successful.

(c) Acid Fluoride Baths

An interesting development in the formulation

of chemical bright dips has been the use of dilute aqueous solutions containing hydrofluoric acid or fluorides together with oxidizing agents, particularly nitric acid. A typical composition covered in patents by Kaiser Aluminum and Chemical Corporation[33] is:—

	By weight
Nitric acid	2.5 per cent
Chromic acid	0.6 „ „
Ammonium bifluoride	0.6 „ „
Glycerol	0.6 „ „
Copper nitrate	0.05 „ „

Temperature 90 to 100°C.
Time 3 to 5 min.

It is claimed that the presence of copper nitrate is necessary to produce maximum brightening except on copper-containing materials. A thin metal smut film may result from the presence of copper and can be removed by dipping in nitric acid or by subsequent anodizing.

A similar bath has also been patented by General Motors Corporation[34] with the following nominal composition:

	By weight
Nitric acid	3.75 per cent
Ammonium Bifluoride	0.65 „ „
Chromic acid	0.65 „ „
Ethylene Glycol	0.60 „ „
Copper nitrate	0.0025 „

Temperature 90 to 100°C.
Time 3 to 5 min.

As these baths are very dilute, their concentration must be maintained either by addition (the amount being determined on the basis of surface area treated) or by the removal of a given volume of solution periodically and its replacement with a newly made solution.

The main advantage of these solutions is their low drag-out losses. However, the finish produced is a rather diffuse brightness with most commercial materials and for many purposes does not compare favourably with phosphoric-acid-based solutions, but the results for high-purity materials are good.

A similar mixture of simpler type has been patented by Vereingte Aluminium-Werke[35] and consists nominally of 13 per cent nitric acid, 16 per cent ammonium bifluoride and 0.02 per cent of lead nitrate operated at 50 to 80° with an immersion time of up to 30 sec. After brightening, the work is kept in a passivating solution which contains oxidizing agents such as an 0.06 per cent chromic-acid solution. This is being used in production for bright anodized aluminium trim on German motor cars. (*See* Fig. 7.)

All the nitric-bifluoride mixtures can give very good results on super purity aluminium (99.99 per cent purity) or on alloys based on it, but are not suitable for lower purities.

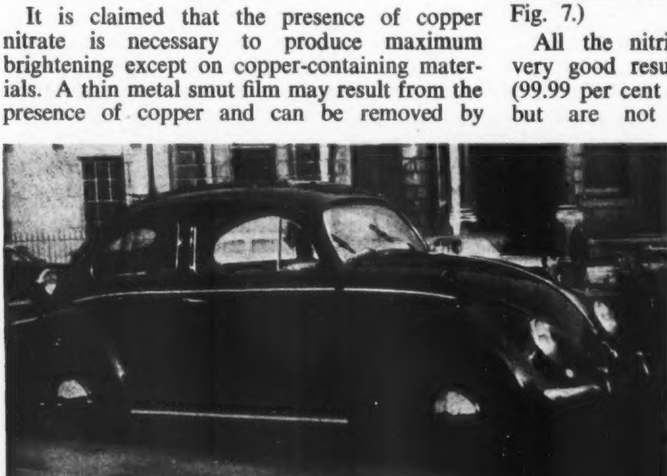


Fig. 7.—"Volkswagen" car with bright-anodized aluminium trim and window mouldings, brightened in the nitric-acid/ammonium-bifluoride bath.

Phosphoric-based solutions give very good results with aluminium up to 99.8 per cent purity and on some alloys, but on higher purities the results are inferior to electrobrightening.

Galvanic Polishing

It is well known that by externally coupling dissimilar metals in a common electrolyte current flows due to their differing solution potentials. It has been established that this effect can be utilized to polish aluminium in an electrolyte similar to those mentioned in the section on chemical polishing. A recently published French Patent[36] covers the principle of polishing aluminium in phosphoric-acid-based electrolytes by coupling with a dissimilar metal or alloy (which may be the bath itself or a graphite electrode) and which is less noble than the aluminium. While use of the bath as an electrode seems improbable, coupling to graphite has practical possibilities.

An application of the same principle is disclosed in the most recent patent[37] from Kaiser Aluminum in which the aluminium articles are

coupled to a gold or platinum electrode, these being immersed in an electrolyte containing 5 per cent nitric acid, 0.1 per cent hydrofluoric acid and 3 per cent glycerol in water. The bath is operated at 90 to 100°C. and a treatment time of about 2 min. is recommended. As far as is known these processes have not been used commercially.

Another example of the same principle is contained in an account on galvanic oxidation of aluminium in nitric acid[38] which also mentions that chemical polishing can be produced by coupling the metal to graphite in a solution containing 800 cc. phosphoric acid, 50 gm. chromic acid and 200 gm. water maintained at 80 to 90°C. The polishing time is less than 10 min.

Discussion

The commercial use of electrolytic and chemical polishing is but a recent development. The mechanism of electrolytic polishing has been studied in some detail on other metals, particularly copper. With aluminium the main work reported has been on perchloric-acetic electrolyte and not the phosphoric-acid-based mixtures used commercially. A further study of these commercial baths would be helpful in providing a more complete understanding of their behaviour.

It should be remembered that electrolytic polishing may not eliminate the need for mechanical polishing since the surface must be fairly smooth for electrolytic polishing to give good results. Since the current used in these processes is high—up to several hundred amp. per sq. ft.—it is by no means certain that it will be cheaper than mechanical polishing, especially on large flat areas where it is known to be more expensive. On the other hand electrolytic polishing of intricate components may often prove the only satisfactory way of producing a high finish.

Where dimensional accuracy is important, electrolytic polishing has limitations. It is well known that in electroplating the throwing power of a solution affects the uniformity of the deposit. The shape of the projections on components and their position in the bath, especially in relation to the anode, cause variations in thickness. In electrolytic polishing the same process happens in reverse and those portions which would tend to build up in plating will be smoothed in electropolishing to a relatively greater degree. Agitation will assist in producing more uniform smoothing.

Electropolishing can be continued almost indefinitely on a component as long as there is enough available acid. It should not be confused with electrobrightening, which only produces microsmoothing and is essentially a process to be used on aluminium of 99.5 per cent purity upwards or on high-purity alloys containing about 1 per cent magnesium. Electropolishing is suitable for most wrought alloys but is only successful on a few casting alloys such as LM5-M, LM11-W or LM7-P.

Chemical polishing is an even more recent development than electropolishing. Owing to the necessity for using concentrated acid solutions, the cost of the initial bath may be rather high—although baths with as low as 50 per cent phosphoric acid, the most expensive constituent, will give good results. To offset this high outlay is the fact that no electricity is used in the process.

Chemical polishing appears eminently suitable for small intricate pressings which cannot be readily polished mechanically, either manually or by barrelling. On large areas the smoothing action of these baths appears more limited and a high finish is dependent upon a good initial mechanical polish. Agitation of the work during treatment is essentially for the best results. The chemical polishing baths which also brighten provide a means of producing a most attractive appearance to large pressings. Little information appears to be available on the cost of treatment, but on small pieces it is likely to be moderate. On casting alloys chemical polishing is successful only with LM5-M and LM11-W.

Apart from phosphoric-acid-based mixtures, the solutions based on acid fluoride dips are worthy of further examination. Being relatively dilute, their drag-out losses are small, which makes for economy in operation. Periodic additions of constituents will be necessary apart from those required to meet normal drag-out loss. The Erftwerke bath is only effective on super-purity aluminium or alloys based on it, and a chemical polishing solution having a similar characteristic but applicable to material of the usual purities would be a desirable development.

Galvanic polishing is the most recent development and it is too early to assess its full possibilites: it may well occupy an intermediate position between electrolytic and chemical polishing. The method certainly appears to justify more thorough investigation, especially as comparatively dilute electrolytes should prove satisfactory.

Apart from the need for a more complete understanding of the mechanism of the process, attention should be given to the problem of regeneration, or the disposal of spent solutions. Where there are high drag-out losses the problem is less serious because additions of the mixture may balance the accumulation of salts.

By carefully selecting their uses and making them corrosion resistant for specific applications, magnesium, aluminium and titanium can be made more useful to many industries.

How Corrosion Studies have influenced Light Metal Usage

By FREDERICK W. FINK*

MANY factors help to determine the usefulness of metals in our economy—cost, availability, weight, strength, and corrosion resistance are only a few. Of major consideration for many applications is a metal's resistance to corrosion. This is especially true for the light metals.

In the early days, the effective use of aluminium and magnesium was handicapped because little was known about their limitations and true potentialities. Both metals frequently failed because they were used improperly. The failures, in turn, tended to discourage their wider application. Their tendency to corrode when used in the forms then available was one of the major causes of failure of both aluminium and magnesium in the early years.

An important factor in the growth of the light metals is, of course, the ability of the industry to reduce production costs. In large part, the supply of the metals depends upon the availability of cheap energy, particularly electric power. Thus the ability of the electric power industry to reduce power costs and of the metallurgists to improve production techniques, which are not considered in this article, will play an important part in the future of aluminium, magnesium, and titanium.

The lightness and strength of magnesium made it a promising metal for many purposes from its earliest development. Yet, its tendency to corrode appeared to belie its promise. In the early years of World War II, however, J. D. Hanawalt and his co-workers at the Dow Chemical Company discovered the importance of metal purity in preventing corrosion in magnesium alloys. They found, for example, that the presence of more than 0.005 per cent iron in the aluminium-zinc-magnesium alloy series increased the susceptibility to corrosion in sea water. They also discovered that nickel and copper impurities had a similar effect. The impurities, in the presence of sea water, are cathodic and cause the generation of an electric current which corrodes away the magnesium.

Improvements in Magnesium

Even a small increase in the amount of some impurities can have devastating effects. Thus, if the iron content of magnesium is increased from 0.005 to 0.05 per cent, the corrosion rate is increased from 30 to 100 times in salt water.

Sometimes the cathodic action of impurities can be prevented. Thus, investigation has shown that the addition of small amounts of manganese overcomes the effect of iron. The manganese tends to precipitate the iron in the melt when the alloy is cast; it also surrounds any residual iron, preventing it from acting as a cathodic impurity.

Early magnesium alloys had flux inclusions which tended to promote pitting when the metal was brought into contact with moisture. Improved melting practice has resulted in cleaner castings and has now eliminated this problem to a large extent. Improvements in degassing practice also have minimized the problem of microporosity in magnesium. For example, the use of chlorine as a degassing agent, which was developed during World War II, is still found helpful in eliminating hydrogen from the melt.

The development of new types of alloys has helped to extend the range of magnesium's usefulness. For example, an alloy with 11 per cent lithium has excellent corrosion resistance and less than usual sensitivity to impurities. It may find application in primary batteries and as a sacrificial anode for cathodic protection. The alloy's limited strength, however, prevents its use in aircraft construction. Other alloys with high strength have been developed, but they have poor corrosion resistance. Cladding of such alloys with the binary alloy tends to protect them against corrosion, but additional research is needed to make such high-strength alloys equally available for use in aircraft and other structures.

Growing Importance of Aluminium

Aluminium, because of its excellent resistance to corrosion as well as its strength, is the most widely used of the light metals. It is especially valuable in applications which call for outdoor exposure. For example, it has withstood atmospheres which contain sulphides, carbon dioxide, sulphur dioxide, traces of hydrochloric acid, and other contaminants. Attack by such atmospheric contaminants is usually slowed by the natural formation of a protective oxide film. The rate of weathering tends to decrease with the passage of time. This is explained by the fact that the pores

* Battelle Memorial Institute.

in the oxide are gradually filled with stable corrosion products. Engineers need give little consideration to corrosion when selecting high-strength aluminium alloys for use in heavy structural installations. However, where it is to be exposed in the form of thin sheets, such as in aircraft, the alloys weather best when clad with pure aluminium.

Aluminium is corrosion resistant to pure water. Nevertheless investigation has shown the danger of using aluminium piping in the ordinary potable water supply system; the presence of even traces of copper or iron in the water, for example, is known to promote corrosion of the aluminium. In cases where the water is circulated in a closed system, however, corrosion inhibitors can be added to prevent attack. Thus, 500 parts per million of sodium chromate added to a slightly alkaline buffered water will keep aluminium bright and free from attack.

Improvements in aluminium solders are also helping to expand the uses of the metal. Recent research has shown that zinc-base solders are corrosion resistant and may be satisfactory for use on aluminium automobile radiators. A new stannous-chloride flux, which is said to facilitate the soldering of aluminium, has been announced. Such developments may make it possible for aluminium to replace copper and brass for auto radiators.

Growing knowledge about the possible uses, as well as the limitations, of aluminium have helped to widen its acceptance. Thus, public confidence in aluminium and its alloys has been increased tremendously by continuing research and developments.

Titanium

Unlike magnesium and aluminium, titanium is a newcomer and has been under investigation for only a few years. Titanium research has been concentrated largely on metallurgical and production problems of the pure metals, but the alloys have also received some attention. Much attention has been devoted also to a study of corrosion resistance.

In general, metallurgists have found that under certain conditions, titanium is one of the most corrosion-resistant commercial metals available. Thus, titanium has no equal among the common metals in its ability to resist the action of sea water According to one recent estimate, the rate of attack in sea water would be only one mil in 1,250 years. Titanium alloys designed for strength and hardness possess similar corrosion-resisting properties.

On the other hand, recent events indicate that titanium is subject to stress corrosion. Several companies have reported that stressed titanium alloys, subjected to red fuming nitric acid, have exploded suddenly after being disturbed in the solution. No adequate explanation for the mechanism is available. But in view of the fact that titanium containers have been used for red fuming nitric acid in rocket experimentation, an investigation of this stress-corrosion problem is needed urgently.

Because of its excellent corrosion and physical properties, metallurgists have estimated that titanium may be substituted for as much as 50 per cent of the stainless steel now in use in chemical plants. They pose the condition, however, that the cost of the titanium must be reduced to less than $3 per pound. If the price is lowered sufficiently, it will also compete with, but not replace aluminium for some applications.

Areas for Future Research

Though aluminium and magnesium have come far in recent years, many problems, which are holding back the extension of their usage, remain to be solved. The metals could be put to many more uses if some of the corrosion problems were solved.

Developing a material resistant to attack by flue-gas condensate is an example of the potentialities of light-metal research. A recent investigation showed that aluminium-coated steel is resistant to attack by such condensate. Is aluminium alone resistant? Would aluminium pipe be suitable for such a purpose? An investigation would be necessary to find out. On the other hand, perhaps the use of ceramic-coated aluminium would solve the problem. Ceramic coating on steel inhibits corrosion by acid condensate, but such coated pipe sometimes fails at the pores. Perhaps aluminium, if more resistant, would not fail. The final answer would call for investigation of the resistance of aluminium to condensate, finding the best ceramic coating for aluminium, and a study of the effect of the condensate on the coated metal.

The growth in size of aircraft has created another serious corrosion problem. Previously, high-strength aluminium-alloy sheets, suitably heat treated and clad, served well in the exposed parts of planes. Now, however, the large sizes of sheet used in the construction of planes present difficulties in heat treatment. Since inadequate heat treatment reduces corrosion resistance, the metallurgist and corrosion technologist must decide what steps might best solve the problem. One possible approach is to modify the heat treatment so that the large sheets can be accommodated. An alternative is to substitute a more corrosion-resistant alloy or one for which heat treatment is less critical. Other possibilities may also present themselves.

Heat-exchanger applications for aluminium

(*continued in page* 332)

Some Metallurgical Properties of Mild Steels

(*continued from page* 317)

Airborne particles are perhaps less troublesome and can be alleviated to a large extent by correct building design. Plant layout, ensures that polishing and grinding operations are kept as far away as possible from presses and steel stores, is a great help. One very prolific source of contamination is the use of portable grinding tools for dressing large press tools that cannot be taken out of the bed. The small particles of metal and stone that fly from the tool are very difficult to remove from greasy tool surfaces unless a great deal of care is given to the task.

Pick-up due to friction between tool and work

The next most prolific cause of trouble is the scuffing which occurs as a result of the continual contact between tool and work. This scuffing is of a mechanical nature and is similar to that which occurs between two bearing surfaces in an engine. The influence of this defect is twofold, it damages the tool first which then damages the work. The cause of this scuffing is a matter of surface physics of a complex nature, the alleviation however is not so complicated and all the following have been used with some success.

1. Phosphate coating of either work or tool.
2. Use of molybdenum disulphide as a tool lubricant.
3. Nitriding of the tool surfaces.
4. Chromium plating of the tool surface.
5. Sulfinizing of tool surfaces.
6. Use of non-ferrous materials such as aluminium-bronze alloys for tools.

Pick-up due to surface defects opening up in steel sheet and strip

An infrequent cause of trouble is the opening up of small laps due to the pressure of tools. When this occurs it often happens that the surface of the lap, which may only be tenths of a thousandth of an inch thick, peels off, and is rolled up between the work and the tool into a ball. This ball of metal is sufficiently work-hardened to enable it to score either tool or work surfaces with ease. This type of defect can give rise to sudden deep damage of a most unwelcome nature. This is one of the problems to which there is no real solution, it is impractical to examine minutely the surface of all materials used, and in any case, the defect is often invisible to the eye and so can be overlooked.

Damage to tools and materials is of great importance in presswork and in metal finishing and it has serious economic aspects, it is false economy to pay a high price for material with a first class finish in order to reduce polishing costs, if when it comes from press tools it possesses scores and damage far deeper than is found on the roughest of hot-rolled surfaces.

This article has considered a few of the aspects of steel sheet and strip, the work referred to in the different sections has its basis in research work which is being undertaken in many establishments to improve the manufacturing and manipulation of steel. The results of these investigations require interpretation into shop production requirements and it is at this stage that the metal-finishing industry can help by applying the results and recommendations on a quantity basis and then returning their results to the research establishments together with observations and suggestions.

Bibliography.

(1) Jones, B., Owen R., Barnett. "Strain Ageing of Mild Steel," *J. Iron and Steel Inst.*

(2) Hundy, B. B. "Roller Levelling of Temper Rolled Steel," B.I.S.R.A. Research Report.

(3) Hundy, B. B. "Accelerated Strain Ageing of Mild Steel," B.I.S.R.A. Research Report.

(4) Waite, J. S., Briggs, G. C. "Experimental Roller Levelling," B.I.S.R.A. Research Report.

(5) Jevons, J. D. "Metallurgy of Deep Drawing and Pressing." Published by Chapman and Hall.

(6) Tipper, C. F. *J. Iron and Steel Inst.*, 1952.

(7) Greenough, G. B. "Progress in Metal Physics."

(8) Cottrell, A. H., Bilby, B. A. *Proc. Physical Society*, 1949, 52(A).

(9) Kenyon, R. L., Burns, R. S. "The Age Hardening of Metals," *A.S.M. Symposium*, 1939.

(10) Polakowski, N. H. *J. Iron and Steel Inst.*, 1952, **172**, p. 369.

(11) Gardam, G. E. "Simple Instrument for Measuring 'Surface Truth' of Metal Surfaces," *Proc. Electrodep. Tech. Soc.*, April 1950, pp. 50/6.

(12) Hundy, B. B. "The Elimination of S.S. in Mild Steel Pressings," *J. Iron and Steel Inst.*, Oct. 1954.

Water Pollution Research Laboratory

(*continued from page* 310)

are interesting possibilities in the development of a biological method of cyanide removal whereby cyanide in concentrations up to about 150 parts per million can be destroyed by using a percolating filter of the same type as is used for purifying sewage. The organism responsible has been isolated and can be cultured. Pilot plants using the process are being tried under industrial conditions by two companies, one of which is engaged in electroplating, and there is a reasonable prospect that the system may be capable of general application in the metal-finishing industry.

G.K.N. Current-density Meter

(*continued from page* 318)

Another feature which improves the performance is that the cores are continually maintained in the cyclicly demagnetized condition (a state where the core "forgets" its previous magnetization history). This is done by pulsing the oscillator several times per second to give four or five cycles of increased voltage output to the bridge. This excess voltage takes the cores into magnetic saturation and subsequently restores them cyclicly to the working level. The input to the detector amplifier is shorted by a relay during this short period and only a slight flicker of the balance meter is apparent.

FINISHING NEWS REVIEW

BARREL POLISHING AS AN INDUSTRIAL PROCESS

New Film produced by Midland Supply House

IN spite of its comparative antiquity as a finishing process barrelling or tumbling still does not command the widespread attention of the engineering industry that its efficiency and economy would appear to merit. There is no lack of examples of components whose complex shape or finishing requirements render hand finishing difficult or expensive which could be effectively subjected to barrel finishing on a semi-mass production basis and to a perfect satisfactory degree of surface finish.

The scope and advantages of barrel finishing are well demonstrated in a new film produced by R. Cruickshank Ltd., Birmingham, under the title "Tumbling into the Future." This film, which had a press showing at the Midland Institute on July 7, had its première during the Annual Conference of the Institute of Metal Finishing at Torquay, last May. It shows, in full colour, the progress of barrelling from its earliest application up to present-day methods and illustrates the wide application of the process to ferrous and non-ferrous metal components. The range of articles shown undergoing treatment varies from costume jewellery and metal ornaments to highly precise aircraft components.

The film lays particular emphasis on the need for careful selection of the correct grade of abrasive medium and describes the production of Aloxite in graded sizes as recommended by the Company for use in their equipment. Reference is also made to the choice of barrel speeds and the incorporation of suitable lubricants and wetting agents. The actual process taking place during tumbling is revealed by a series of slow-motion shots taken in a special demonstration barrel.

It is not claimed by Cruickshank's that it is possible by barrelling to eliminate orthodox hand finishing methods completely, but on suitable components a standard of finish can be achieved which is suitable for subsequent bright nickel and chromium plating without any intermediate polishing, which can show a substantial economy in production costs.

The film constitutes a record of seven years research and development work on barrel processing by the Company and certainly deserves to be widely seen by manufacturers and engineers. It can certainly be said that anyone unfamiliar with the barrel-polishing process will find in it much to interest him and will be stimulated to investigate the possibilities of the application of the process to his own production.

FORD ENGINEERING RESEARCH CENTRE NEARS COMPLETION

Investigation of Finishes among Research Projects

ON a site of just over 65,000 sq. ft. originally used by a firm of glassware manufacturers for over 150 years, the Ford Motor Company Ltd. has erected in Birmingham one of the most modern engineering research centres possessed by the British motor-car industry. Work on this laboratory is now nearing completion and already today well over two hundred highly skilled engineers are embarking on long term research on the results of which will be based many of the activities of the main factory at Dagenham in future years. A considerable amount of demolition and reconstruction work has been carried out, the main office block being completed during 1952 and 53. During a recent visit it was possible to inspect the facilities now available for research on passenger vehicles, car units and tractors, together with the complementary machine shop and cost and weight analysis service.

The activities at the Birmingham Centre are closely co-ordinated with the work at Dagenham, to provide an engineering team capable of dealing with both current engineering problems and long term development and research. The Centre forms a complementary part of the Design Engineering Division at Dagenham and comes under the overall control of Mr. M. Ronayne, the chief engineer. The resident administration manager at Birmingham is Mr. G. T. H. Tunna.

The work carried out at the Birmingham Centre is principally long term applied research, rather than solving of everyday problems. In addition to the development of complete vehicles considerable research is aimed at the improvement of components of existing models, the specification of new materials, and the production of designs to make more effective use of modern manufacturing methods. At the present time the Centre has the following facilities; A well-equipped machine shop in which it is possible to undertake the machining of all the mechanical parts normally made at Dagenham except for cam shafts, spiral bevels and finish grinding of pistons. A vehicle garage used for the installation of experimental units and road testing of prototypes; a tractor build and rig test and an engine test. In the Physics Laboratory test equipment is being developed to investigate basic engine problems, while the Metallurgical Laboratory contains some of the most modern and costly equipment in the industry for mechanical testing. The work of the Chemical Laboratory, where work is carried out on plastics, oils and similar materials, in addition to such finishing materials as paints, and electroplates, is supplemented by the Paint Laboratory, which is equipped with a spray booth and a stoving unit.

Quite recently a further 25,000 sq. ft. of property adjoining the site has been acquired for the construction of a heat-treatment laboratory.

The Ford Motor Co. Ltd., have always shown themselves to be important and progressive users of metal finishes, and there can be no doubt that the new long-term facilities now available at the Birmingham Centre for investigation into the application of finishes to motorcars can be expected to show results before very long.

TECHNICAL AND INDUSTRIAL APPOINTMENTS

After serving several years with the company Mr. Aubrey Wallace Barr has been appointed to the board of **Cellon Ltd.** This represents a continuance of family interest in the direction of the company as Mr. Barr is the son of the late founder of the company, Mr. A. J. A. Wallace Barr.

* * *

The appointment of Dr. J. W. Barrett, B.Sc., D.I.C., F.R.I.C., A.M.I. Chem.E., as a director of the company has been announced by **Monsanto Chemicals Ltd.**

Dr. Barrett first joined Monsanto in 1941 as a group leader in what was then the research department. He was appointed assistant director of research and development in 1950 and later in the same year became general manager of the development division. In 1954 he was appointed a member of the company's executive committee.

As a director he will continue his present responsibility for the company's research and development activities.

* * *

Mr. J. E. Spence, M.I.Mech.E., until recently export sales manager of **B.E.N. Patents Ltd.**, has now been appointed general sales manager of the company.

* * *

A number of appointments have been announced by **Evode Ltd.**

Mr. E. A. Duligal, B.Sc., A.R.I.C., A.R.T.C.S., has been appointed technical manager of the Paints division. Formerly, Mr. Duligal held successively the positions of senior research chemist at North British Chemical Co. Ltd., (Paints Division), and technical director of G. A. Willis (Middlesbrough) Ltd.

His new appointment presages considerable expansion of the company's Paints division.

Mr. J. H. Briant, Assoc. I.N.A. has been appointed technical manager of the Mastics division, having been for the previous five years engaged in the development of mastics and sealing compounds with J. B. Products Ltd.

Mr. T. S. James, formerly Northern Sales manager of Montgomerie, Stobo and Co. (Chester) Ltd., has been appointed as Paints Specialist to the executive staff.

NEW EXTENSION T RESEARCH AN

in the Manufacture and Application of Paint

ON June 28, a new wing to the research and development laboratories of the Paints Division of I.C.I. Ltd., was formally opened by Alderman A. W. J. Pusey, the Mayor of Slough, in the presence of a number of representatives of local educational and employment organizations. The Mayor was received by Mr. L. H. Williams, chairman of I.C.I. Paints Division, who briefly welcomed the guests, and by Mr. C. Paine, the I.C.I. Development director.

Following the official opening the party was conducted on a tour of the various laboratories in the new wing and was afterwards entertained to tea by the company.

The opening of this new extension reflects the growing appreciation by the company of the importance of development work in industrial paint usage. It is intended that these laboratories will not only expedite the application of research results to industrial processes, but also by maintaining contact with industrial users of paint they will ensure that current problems and needs attendant upon paint usage are kept constantly under review.

In addition to the Laboratory at Slough, the Paints Division has further research facilities at Stowmarket, in Suffolk, where it also operates a large exposure site for carrying out paint weathering tests.

The Development Department makes use of a staff of over one-hundred and fifty divided into sections of from six to ten men each under the direction of a senior graduate. Each section deals with paints devised for a

(*left*) *A view along the first floor corridor of the new laboratory wing, showing the curtain-wall partitioning and the Frenger ceiling with recessed lighting fittings.*

(*below*) *Part of the laboratory devoted to development of new industrial paints.*

FACILITIES FOR DEVELOPMENT

A view of the exterior of the new building forming an extension to the development laboratories of I.C.I. Ltd., Paints Division.

particular industry or group of industries, whereby each section acquires a specialized knowledge of the requirements peculiar to particular industries.

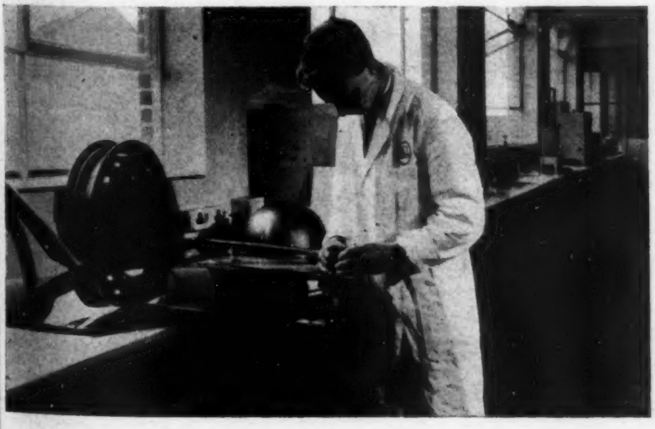
The New Laboratory

The new wing of the development laboratory at Slough has doubled the existing accommodation for the Development Department. Unlike the older laboratory, which was a single story building, the new building is on two floors and the design has been such as to give a considerable degree of flexibility in internal arrangements. Thus internal columns have been eliminated, extensive use being made of demountable partitioning, and such services as water, electricity and compressed air have been incorporated to a considerable extent in the longitudinal 4 ft. module of the building.

In addition to up-to-date laboratory-scale paint-making machinery, paint-testing equipment and photographic laboratories, the new block is also provided with two controlled atmosphere testing rooms for the study of the behaviour of paints under widely varying conditions of temperature and humidity. In one of these rooms the temperature can be maintained at any level in the range 0 to 40° C. with a relative humidity of 50 to 95 per cent at any temperature in the range. The second room is not provided with controlled humidity, but provision is made for controlling the temperature between ambient and 40° C.

During the course of the official visit to these laboratories time did not permit a close study of the work in progress, but from the facilities available and the approach to the problems in hand, it can confidently be expected that the part which the I.C.I. Development Department has played in contributing to the substantial and progressive improvements in paints over the past twenty years will not only be maintained, but made of even greater significance in the years ahead.

A thickness meter in use for determining the film thickness of a stoving finish for car bodies.



NEWS IN BRIEF

Paripan Centenary

To commemorate the centenary of the foundation of the company all members of the staff of **Paripan Ltd.**, were entertained to a dinner and dance, held in a large marquee erected in the grounds of the home of the chairman and managing director of the company, Mr. P. G. Randall.

Presentations were made to employees who had served the company for over forty years, and three presentations were made to the chairman and his wife on behalf of the directors, and of the staff at Egham and London.

Blundell, Spence acquire office

A 42-year lease of York House, Queen Square, Holborn, W.C.1., formerly occupied by the National Deposit Friendly Society, has been acquired by **Blundell, Spence and Co. Ltd.**, paint manufacturers since 1811.

York House has been substantially reconstructed following war damage; the rear part of the building, which was entirely demolished is at present being completely rebuilt.

* * *

A new depot of **Permoglaze Ltd.**, was opened on June 3 at 11/12, Adam Street, Cardiff.

* * *

As from May 2 last, the address of **Economic Utilities Ltd.**, is Royal London House, Finsbury Square, London, E.C.2. Tel. METropolitan 0414.

Latest Developments in PLANT, PROCESSES and EQUIPMENT

Diesel-driven Compressor

THE construction of a small portable diesel-driven air compressor in the 10-to 15 cu. ft. per min. class has awaited the availability of a suitable air-cooled diesel engine.

The introduction of the Lister type LD3½ h.p. diesel engine has now made it possible for B.E.N. Patents Ltd., High Wycombe, Bucks, to produce their P.12 portable compressor unit incorporating this engine. This equipment shown in Fig. 2 is designed for continuous spray painting as well as operating small pneumatic tools, and is very suitable for use by painting contractors.

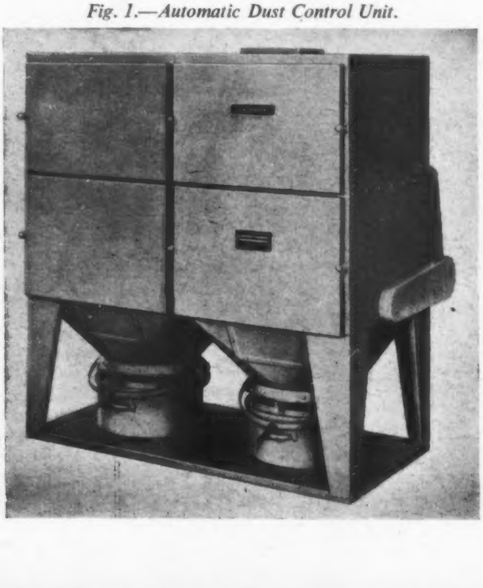
The compressor displaces 14.4 cu. ft. of air per minute and develops working pressures of 20 to 80 lb. per sq. in. Control is by an adjustable air governor, and a coiled copper after cooler in conjunction with a fan-type flywheel ensures efficient cooling. An oil and moisture separator with pressure reducing valve is fitted as standard, while the provision of pneumatic tyres makes for easy manoeuvring over rough ground.

Air Filtering Valve

THE complexity of modern finishing problems has made clean air for spray painting a vital necessity. A move to meet this need has been made by Alfred Bullows and Sons Ltd., Walsall, Staffs., by the incorporation of further improvements to their V.3755 air filter and reducing valve unit.

The main filtering medium now consists of a stack of phenolic resin mouldings (see Fig. 3) which

Fig. 1.—Automatic Dust Control Unit.



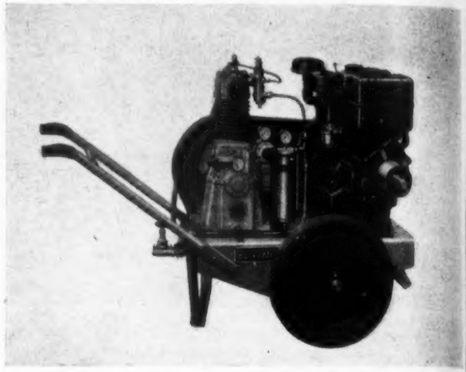
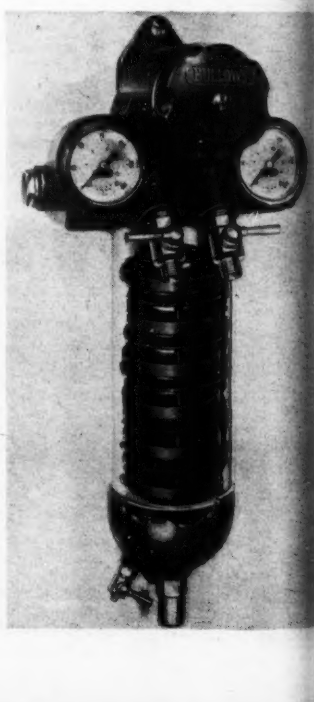


Fig. 2.—Diesel-driven Air Compressor.

represent the result of extensive tests and development work to provide a completely non-clogging and self-cleaning medium. The air passages provide a series of carefully controlled changes of direction and velocity, so that, with negligible resistance to flow, all

(*Continued in facing page*)

Fig. 3.—Air Filtering Valve.



Development in Plant, Processes and Equipment.
(Continued from previous page)

condensed particles of water are thrown out of the air stream and returned to the sump for discharge to atmosphere. This same filtering medium is also available in the E.100 air filter.

Automatic Dust Control Unit

UNIT dust collectors of the fabric type have, in the past, been designed for hand shaking of the filter media. A new device has now been designed to ensure adequate and effective shaking at predetermined intervals, thereby eliminating the human element. This automatic shaker can be applied to the complete range of fabric-type filters manufactured by Dallow, Lambert and Co. Ltd., Spalding Street, Leicester. It consists essentially of special control gear which governs the electrically driven shaking mechanism. This control gear is interlocked with the fan motor starter so that the shaking time cycle is commenced whenever the fan motor is switched off. After a suitable time interval, in which the fan impeller comes to rest, the shaking mechanism comes into operation for a set period of time. As it is essential that the filter should not be shaken while air is passing through the fabric, the control gear is arranged so that during both the first time interval and the shaking period, and also for a short time after shaking, it is not possible to restart the fan. After the time cycle has been completed, the mechanism resets itself ready for the next operation. As a further refinement, the electrical controls can be interlocked with the machine or operation which is being served by the dust collector.

In Fig. 1 the automatic shaker is applied to a Dallow Lambert Dustmaster DM100 series, type 201 unit dust collector.

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Polishing and Brightening of Aluminium

(*concluded from page* 323)

Eventually the problem has to be faced of disposal of the bath, which may freeze solid if allowed to cool. The mixture is in any case a rather expensive loss. It is to be hoped that some ion-exchange system can be devised, to regenerate the acids from the salts formed, at a cost which would make possible a useful saving through this recovery. From every point of view the development of more dilute solutions would be beneficial and this offers fruitful possibilities for further research.

References

(1) Burns, R. M., and Warner, C. W. U.S. Patent 1,658,222, 1928.
(2) Jacquet, P. A. *Comptes Rendues*, 1935, **201**, p. 1473.
(3) Jacquet, P. A. *Bulletin de la Société Chimique de France*, **1936**, 3, p. 705.
(4) Plateau, J., Wyon, G., Pillon, A., and Crussard, C. *Metaux*, 1951, June, 310, pp. 235-249.
(5) Hickling, A. and Higgins, J. K. *Trans. Inst. Metal Finishing*, 1953, 29.
(6) Jacquet, P. A. "Electrolytic Polishing of Metallic Surfaces and Its Applications" (1948), *Editions Métaux*, pp. 308-312.
(7) Brit. Patent 687, 774—Vernal S.A.
(8) Brit. Patent 558, 925, 1942, E. Windsor-Bowen (*see* also Canadian Patent 423, 093—Alcoa and O. L. Shawcross).
(9) Brit. Patent 613, 487, 1946, Aluminum Company of America.
(10) Brit. Patent 619, 336, 1947—High Duty Alloys Ltd., and L. Whitby.
(11) Brit. Patent 612, 478, 1946—United Anodizing Co. Ltd., and MacArthur, Westwood and Napier.
(12) Brit. Patent 526, 854, 1939—Battelle Memorial Institute.
(13) Brit. Patent 645, 453, 1948—Battelle Memorial Institute.
(14) Brit. Patent 675, 186, 1949—Rolls Royce Ltd.
(15) Brit. Patent 638, 321, 1947—S A. pour la Protection et la Colouration des Métaux and Tréfileries et Laminoirs du Havre.
(16) French Patent 961, 236, 1948—Compagnie de Produits Chimiques et Electrometallurgies Alais, Froges et Carmargue.
(17) Brit. Patent 654, 455, 1951—M. Damien S.A.
(18) Brit. Patent 433, 484, 1934—Aluminum Co. of America and R. B. Mason.
(19) Brit. Patent 489, 169, 1936—Aluminum Co. of America and R. B. Mason.
(20) Brit. Patent 436, 481, 1934—Aluminum Co. of America.
(21) Brit. Patent 436, 154, 1934—Aluminum Co. of America.
(22) Brit. Patent 449, 162, 1935—British Aluminium Co. and N. D. Pullen; also N. D. Pullen, J. Inst. Metals, 1936, 59, 151-158.
(23) Brit. Patent 624, 484, 1947—Aluminum Co. of America.
(24) Brit. Patent 655, 699, 1948—Société des Produits Chimiques des Terres Rares.
(25) Brit. Patent 627, 854, 1946—United Anodizing Ltd., Napier, D. H., and Westwood, J. V.
(26) Brit. Patent 625, 834, 1946—United Anodizing Ltd., and Shelton-Jones, E.
(27) Henley, V. F., *Electrical Review*, 1949, Aug. 21, pp. 213-215.
(28) Herenguel, J. *Revue de Métallurgie*, 1951, **484**, pp. 262-266, and French Patent 984, 863.
(29) Hug, H. *Aluminium Suisse*, 1952, 1 (2), pp. 4-13.
(30) Brit. Patent 687, 774, 1949—Vernal S.A.
(31) Brit. Patent 675, 444, 1950—Vernal S.A.
(32) French Patent 1,007,070, 1948—Vernal S.A.
(33) U.S. Patents, 2,593,447, 2,593,448, 2,593,449 2,620,265 and 2,640,806, 1949—Kaiser Aluminum and Chemical Corporation, and Hesch, F. H.
(34) U.S. Patents 2,614,913, 1950, and 2,625,468, 1951—General Motors Corporation, S.R. France, and Reindl, H. J.
(35) Brit. Patents 693,776 and 693,876, 1950, Vereingte Aluminium-Werke.
(36) French Patent 1,011,086, 1948.
(37) U.S. Patent 2,640,806, 1949, Kaiser Aluminum and Chemical Corporation, and Hesch, F. H.
(38) *Revue de l'Aluminium*, 1953, **197** p. 94.
(39) *Revue de l'Aluminium*, 1953, **198**, pp. 131-135.
(40) Brit. Patent 627,854, 1946—United Anodizing Co., Napier, D. H., and Westwood, J. V.
(41) Hoar, T. P., and Mowat, J. A. S. *J. Electrodepositors Tech.Soc.*, 1949-50, **26**, p. 7.
(42) Figour, H., and Jacquet, P. A. French Patent 707,526, 1930.
(43) Fischer, H.—Paper to Deutsche Gesellchaft für Metallkunde Annual Meeting, 1952, also *Met. Ind.*, 1952, 8075 (Abstract).
(44) British Patent 659,747, 1948, Aluminum Company of America, and Cochran, W. C.
(45) Italian Patent 464,725, 1951, Alluminio Lombardo Premoatesa.

Note: The year given after patent numbers indicates the application date of the patent.

Corrosion Studies influence Light Metal Usage

(*continued from page* 325)

would be more widespread if some of the corrosion problems could be solved. Thus, the metal is used in nuclear power plants for handling high-purity water at elevated temperatures. Under some conditions, not thoroughly understood at present, aluminium fails by corrosion. Further research on this problem could greatly expand the possible uses of aluminium in heating equipment, automobile radiators, and similar applications.

For both magnesium and aluminium, corrosion is frequently localized at joints, seams and contacts with other metals. Wider application of light alloys depends to a large extent upon the development of joints superior in corrosion resistance and strength to those now available.

Magnesium and its alloys would enjoy broader applications if the effects of purity and composition in corrosive environments were more thoroughly understood. With increased knowledge, magnesium might find uses under conditions of tropical humidity, where contact with foodstuffs is necessary, and where contact with body fluids is required. Availability of magnesium alloys for use in such environments would greatly broaden the demand for the metal.

The solution of corrosion problems would also speed up the development of titanium. Currently available commercial-grade titanium tends to vary considerably in purity from lot to lot. Determining if any of these variations adversely affect the corrosion properties of the metal would definitely aid in the advancement of titanium's technology.

Improved corrosion resistance would, of course, increase the conventional usages of the light metals. Engineers are devoting increasing attention to high-strength, lightweight designs for many devices that move, have to be lifted, or are used in transportation. For air transport, for example, greater speeds and higher fuel costs demand economies in the total cost of operation. The same factors operate in the fields of rail and automotive transportation. The light metals offer a most fruitful approach to this problem.

Granted that their technology holds a favourable course, it may be that aluminium, magnesium and titanium will rank next to steel, possibly in that order, a quarter-century from now.

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